REFRACTION AND VISUAL ACUITY

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WITH SIXTEEN ILLUSTRATIONS
AND A COLOURED PLATE

NEW YORK
REBMAN COMPANY
1123 BROADWAY

INTRODUCTION

THE following pages are principally intended to assist the general practitioner of medicine; who, more and more, feels the need of a closer acquaintance with the errors of vision and their correction; and who frequently finds it difficult to attend a practical course of post-graduate instruction on the subject.

The effort has been made here to avoid abstruseness, and confine attention simply to the most essential points: reference has been omitted to rarer questions, for which standard works are available.

Best thanks are due to the members of the different branches of His Majesty's Services; to the Officials of the Railway and Shipping Companies, both at home and abroad; and to all others who have been kind enough in troubling to supply the various points of information which are presented in the latter part of this book. Also to Mr. Albert Campbell, of the National Physical Laboratory,

at Teddington, for his kindness in checking the calculations in the table of inter-pupillary distances; and to Mr. H. Favarger for similarly revising the portion relating to questions of school architecture and planning.

KENNETH SCOTT.

7 Manchester Square,
London, W.
March 1911.

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PART I

REFRACTION

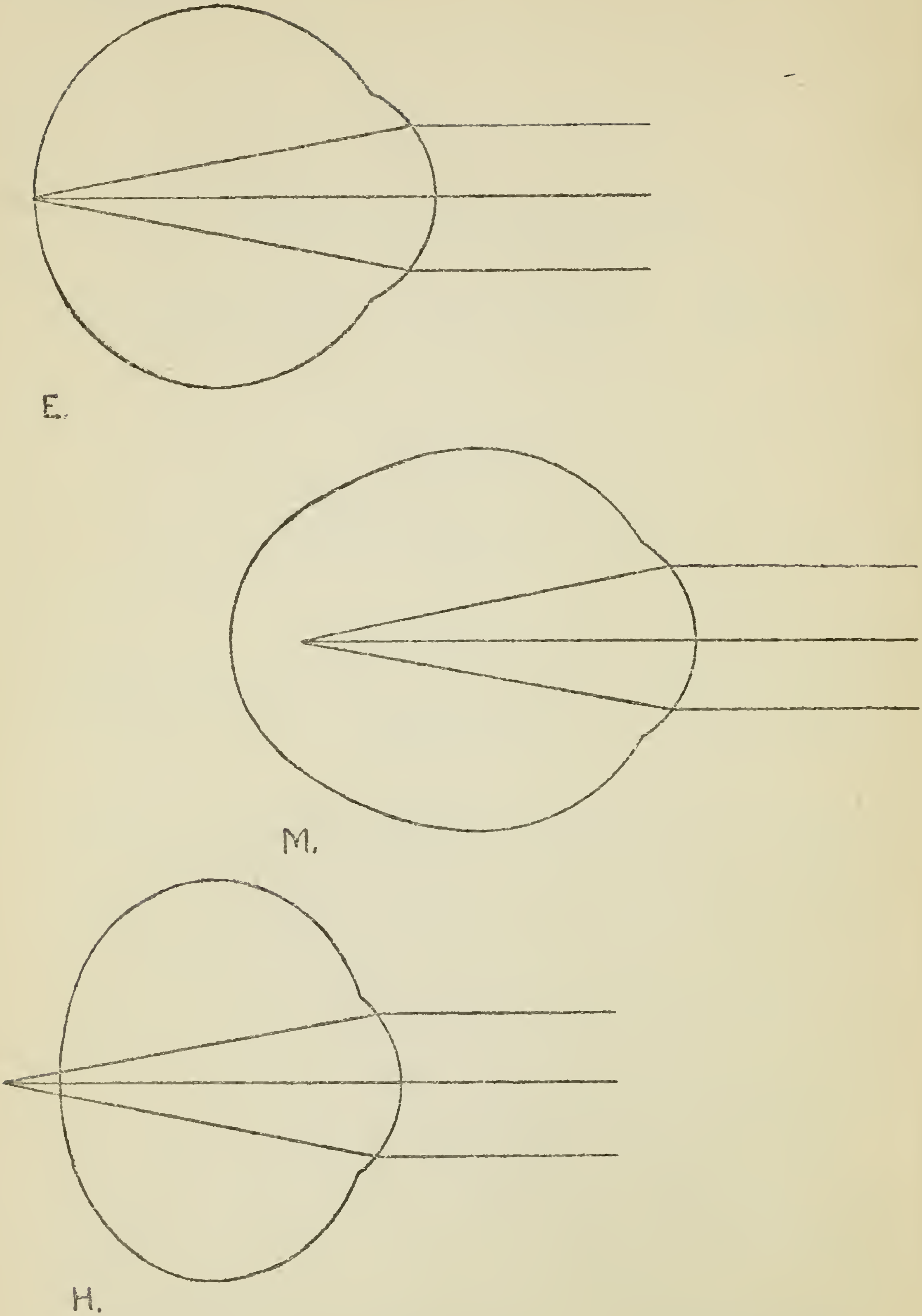
CHAPTER I

REFRACTION OF THE EYE AND CORRECTION OF ERRORS

WHILST an intimate knowledge of optics is naturally an advantage when considering the subject of spectacles, yet it is not entirely necessary. Much can still be done that is of full practical service if the following essential facts, briefly described here, are borne in mind. But in order to attain success, each case must always be studied and treated with scrupulous regard to accuracy in every detail.

In the normal eye rays of light which are parallel — those emanating approximately from a distance of 6 metres or further — meet in focal point on the retina to form a clear and distinct image there (Fig. 1, E). Vision with the normal eye is known as a condition of **Emmetropia.**

(Diagrammatic.)



E = Emmetropia. M = Myopia. H = Hypermetropia.

FIG. 1.

In **Hypermetropia** (or Hyperopia), the eye is flattened in its antero-posterior axis; parallel rays consequently come to a focus behind the eye—beyond the retina; thus producing on the latter only a blurred image of the object looked at (Fig. 1, H).

In **Myopia** the portion of the globe of the eye posterior to the ciliary region is elongated, and parallel rays therefore come to a focus in the interior of the globe before they reach the retina: this, likewise, prevents a clear impression of the image being perceived there (Fig. 1, M).

In newly born children the eye is usually a hypermetropic one, being congenitally shallow in shape; but as the child grows older the axial length increases proportionately, so that ultimately the eye, in ordinary course, becomes an emmetropic one: but if for any reason this normal development is retarded, hypermetropia may persist. If, however, the elongation is excessive, a condition of myopia results.

Astigmatism is the term used to describe that condition of error in refraction when the curvature is found to be greater in one meridian than in another: in other words, it is equivalent to excess of curvature in one direction. It occurs in various forms. There is **Simple Astigmatism**, either hypermetropic or myopic: here the eye is emmetropic with the exception of such error in one direction, or meridian. In **Compound Astigmatism** the eye is already hypermetropic or myopic, and the astigmatic error of corresponding character is superadded. In some other cases the eye may be hypermetropic in one meridian and at the same time myopic in the other, which is usually at right angles to it: this is known as **Mixed Astigmatism**. In **Irregular Astigmatism** the

refraction varies even in the same meridian, and a distorted visual impression is produced on the retina in consequence: this occurs when there is irregularity of the corneal surface, or there is alteration in the substance of the lens—as in incipient cataract, or when it is partially dislocated.

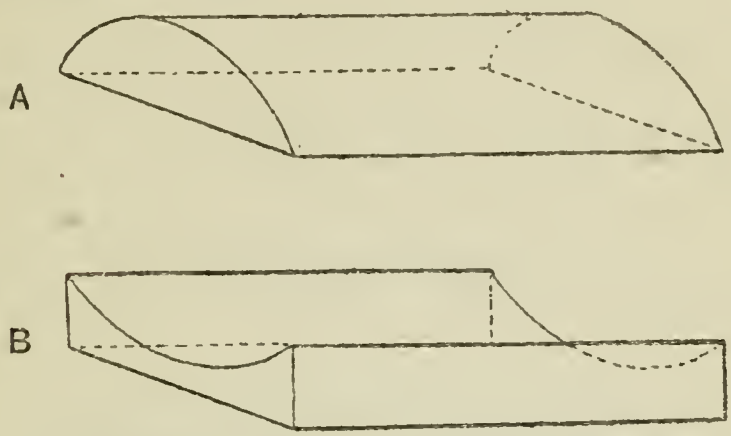
The measurement of the amount of astigmatism present in a case, is represented by the difference in degree between the lowest and greatest errors of refraction in the same eye; and it is found that these two meridians are almost invariably placed at right angles to each other.

All errors of refraction are collectively known as **Ametropia** (the converse of Emmetropia); and when the error of refraction differs in nature in the two eyes, it is known as **Anisometropia**.

Defective vision due to refractive error is remedied by interposing suitable lenses before the eye, so that a normal condition is produced: then parallel rays of light entering the eye focus on the retina precisely and form a clear image there.

The lenses in general use are either convex or concave: the former are used to correct hypermetropia, and the latter are employed in myopia. Both these lenses occur in two forms, spherical and cylindrical. A spherical lens has the same radius of curvature in every meridian, and is used in simple hypermetropia and myopia: a cylindrical lens is curved in only one direction, the meridian at right angles to it being perfectly flat (Fig. 2). These may be used, in accordance with requirements, either alone or in combination with each other. In the latter case, it is usual for the spherical correction to be ground on one side of the lens, and the

cylindrical correction to be on the reverse surface. In some instances it is necessary to grind a cylinder on each surface of the lens, their axes being at right angles to each other.



A = Cylindrical convex. B = Cylindrical concave.

FIG. 2.

A convex lens (Fig. 3) is distinguished by being prominent on either one or both surfaces, and is known as a *plus* (+) lens; and when moved up and down or from side to side, in front of the

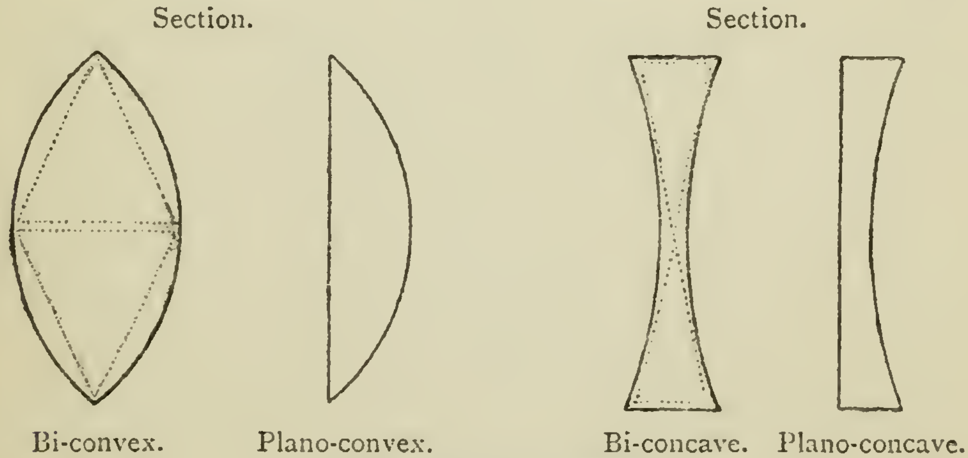


FIG. 3.—Spherical lenses.

observer's eye, objects seen through it seem to move in a contrary direction to, or against, the lens. A concave lens represents a hollowed surface on one or both sides, and is known as a *minus* (−) lens: when

similarly examined, distant objects seem to move in the same direction, or with the lens. When a convex and a concave lens of the same strength are placed with their surfaces in close apposition together, and are moved about before the observer's eye in this way, distant objects appear to be motionless: the two lenses are then said to neutralise each other. This is one method of ascertaining the strength of an unknown lens: the comparison being made by using standard lenses of known strength in the trial-case.

Lenses for optical purposes are classified in the metrical system; the unit in the scale of measurement being known as a Dioptre. The standard of one dioptre power (D. = 1) is equivalent to a convex lens which causes parallel rays to converge, so that the focal point is at the distance of 1 metre from the lens: on the other hand, the concave lens of one dioptre, is one that perfectly neutralises the foregoing, so as to give the effect of plain glass.

Both convex and concave lenses are subdivided into spherical and cylindrical glasses.

These lenses are arranged in a box, or trial-case, in their respective series: the separate rows of convex or plus lenses—both spherical and cylindrical—are usually ranged to the right; whilst similarly all the concave or minus ones are to the left side.

Although the rows of convex and concave lenses appear at first sight as two distinctly separate series, they, in reality, together form one continuous scale: they are merely separated one from the other by a lens—theoretically present—that corresponds to plain glass, and which would form the zero-point.

This may be likened to the degrees marked on

the scale of a thermometer which, for greater convenience in the box, has been bent into the form of a U, with zero, which would be represented by plain glass, placed at the lowest or turning point. The highest figure at the top of the scale is represented by the strongest convex lens; and the numbers decrease downwards still further until the strongest, or most hollowed, concave lens is ultimately reached; but this, owing to the scale, as it were, being bent upon itself, is found at the highest point on the opposite side.

This view of the lenses applies equally to both the cylindrical and the spherical glasses. It is a fact that should be constantly borne in mind, as it simplifies the few rules and the manner of using them, and renders intelligible what otherwise might appear contradictory.

As the effect of convex lenses is to decrease the focal length—referring to the optical system of the eye—they are therefore used to correct hypermetropia; and concave glasses, which lengthen or extend it, are used for myopia. In both instances the object is to modify the focal distance, so that the visual impression received from outward images falls, or is focused, within the eye exactly on the retina. The modification of the focal distance by means of lenses becomes necessary in cases where, owing to anatomical aberration, the mechanism of the eye is not able to fulfil its functions properly in this respect.

In the use of lenses it is essential to place them correctly in position on the face, so that their centres coincide accurately with the visual line in each eye; this is the imaginary line connecting the object at the point of fixation with the macula of the retina.

Every lens presents two centres for consideration, the optical centre and the geometrical one; and these are not always necessarily the same. For practical purposes the optical centre of a lens is that line connecting the two surfaces along which any ray in passing is not deviated. (This will be explained more fully when describing the centring of spectacles.)

When a transverse section is made through the centre of a lens, it is apparent that it practically consists of two prisms: these are placed with their bases together in a convex lens, and with their apices together in a concave one (Fig. 3). The action of a prism, formed of clear glass, on a ray of light passing through it, is to divert its path and deflect it to the one side—towards its base; and the thicker, or stronger, the prism, so much the greater is this deviation.

It is easy, therefore, to understand that when the rays of light are transmitted through the centre of a convex lens, they are deflected in equal measure by each opposing set of prisms; with the result that the rays meet together in focus beyond it. If, however, the rays of light pass to one or other side of the optical centre, this action of the prisms becomes correspondingly unequal; or, depending on the situation, the glass no longer modifies the rays of light after the manner of a true lens, but, instead, introduces the combined effect of a lens and a prism. The foregoing also applies in respect to a concave lens.

In order to control the centring of the lenses in front of the eyes, as well as for holding them there, an adjustable trial-frame (Fig. 4) is used when testing the vision.

This is in the form of a model spectacle-frame, which has extra grooves or cells on the front to hold more than one lens, when there is need to combine them. The thin, flat metal plate forming the front of each eye is marked off into degrees of a circle, with the zero-point at the horizontal meridian: this indicates the position of the axis when cylindrical lenses are used. It is found convenient in practice for this scale to be marked so that it reads from left to right and downwards, and exactly the same in

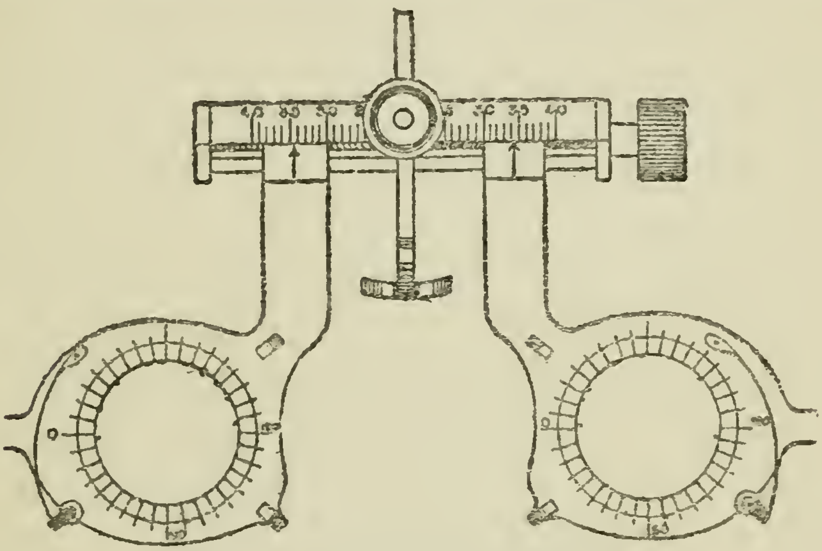


FIG. 4.—Adjustable trial-frame.
(Sides and operculum flaps are omitted in the diagram.)

both eyes. (Some, however, advocate an arrangement by which the zero-point is placed at the nasal side of each eye; so that in the right, the scale would read backwards—contrary to the natural act of reading,—but in the left eye it would read forwards; this is not only confusing when speaking of the lenses, but is apt to lead to error.) The two eye-plates of the front are movable by means of a milled screw, so that in the horizontal direction they can be separated or brought closer together; their position can thus be readily adapted to the individual

requirements of each case. Also, by means of a sliding arrangement, special adjustment can be made in those not uncommon instances where one eye is further removed than the other from the middle line of the nose.

For the purpose of arriving at the proper estimation of the inter-pupillary distance, two clear glass discs are used in conjunction with the trial-frame: each of these has two narrow opaque lines marked on it at right angles to each other, with their point of intersection exactly at the centre. When placed in the trial-frame the lower end of one vertical line in each disc is made to rest exactly against the 90° marked on each eye there.

The observer sits facing the patient, using one eye only, and from a fixed point—as in looking through the aperture of an ophthalmoscope, or a retinoscopy mirror, held between the fingers. The patient's gaze is directed towards the aperture of the mirror from the nominal distance of 1 metre, which for greater convenience in working, approximates to 90 centimetres, or 36 inches. The head both of the observer and the patient meanwhile must not to be moved. The macula, and with it the visual axis, of both eyes of the patient, are thus brought into line with the eye of the observer. By gradual adjustment of the trial-frame the centre of the cross-lines on each disc is made to exactly coincide, at one and the same time, with the respective centre of each pupil; and the pointer, moving against the millimetre scale on the flat top-bar of the frame, then indicates the measurement of the inter-pupillary distance. It is advisable to make a practice occasionally of verifying the cor-

rectness of this measurement, by use of a millimetre rule laid across from point to point, in case the frame becomes inaccurate by wear or accident.

It is not unusual to find that the eyes are set in the face at different levels; but this does not affect the inter-pupillary distance, which is dependent solely on the degree of lateral separation. When, however, each eye is examined separately with the lenses, the front of the trial-frame must be raised or lowered vertically, so that the centre of the cross-line glass corresponds at the time with the centre of the pupil of the eye under examination.

In using the lenses in the trial-frame care should be taken that they approach as closely as possible to the eyelashes, but without touching them. This movement is also controlled by the position of the bridge.

When the gaze of an individual is directed towards an object at 6 metres or further away —which in practice is equivalent to the term "infinity,"—the visual axes of the two eyes can be regarded as being parallel to each other. In the act of reading—the ordinary distance for which is 30 cm., or 12 inches—the eyes naturally converge, and in doing so rotate laterally inwards, practically 3 mm., towards the vertical middle line of the face. Thus the total alteration in the inter-pupillary distance is 6 mm. between the relative position of the eyes when used for distance and for reading. Unless appropriate allowance is made for this change in cases where lenses are required, the alteration in the position of the eyes brings about a condition similar to that which would be caused by mal-placed lenses acting wrongly as prisms; and

this is a frequent source of aggravated trouble to the patient who is unaware of the reason for it.

The effect of a prism thus unintentionally produced, makes the image of an object looked at to become deflected from its real position and fall on dissimilar portions of the retina in each eye; so that the impression of a double, instead of a single, image reaches the brain. The patient may also observe that objects looked at either seem prominently rounded (undue convexity), or appear hollowed (undue concavity).

In order to nullify this undesired result, the extrinsic muscles of the eye act intuitively in an abnormal manner, and a condition of strain is produced, with ultimate harmful effect, which extends even to the general nervous system of the body. The patient begins to complain of various symptoms, which may at first be somewhat ill-defined; but later, they are recognised perhaps as a feeling of discomfort or congestion about the eyeballs; pain or neuralgia either quite locally, or in adjacent tissues, or at times more remote; also attacks of giddiness are occasionally experienced.

The ill effects of lenses that are wrongly decentred is more apparent in the higher degrees of error; but in a very large proportion of those with quite a low degree of fault, similar intolerance is displayed, although the symptoms in this latter may be more insidious and be delayed.

It has been customary when such symptoms are traced to the eyes, to group the greater part of the cases under the category of Heterophoria—which is a generic term describing a state of imbalance in the ocular muscles. Different measures have been

devised for their relief—operative or otherwise; but in the majority of instances when their glasses have been correctly centred, these untoward symptoms, as a rule, speedily subside: and in others, who require to wear glasses, this point is one of equal importance when they come to be ordered.

It should be an invariable rule to ascertain the inter-pupillary distance in every case at the time the vision is tested. This, by controlling the position of the lenses during the examination, it will be understood, ensures greater accuracy in detection of the existing error, as well as yielding better visual results afterwards. Moreover, it provides a basis for the same detail if spectacles are subsequently prescribed; and thus, secondarily, prevents the occurrence of ocular strain, with its risk of wider extension and consequences.

There is another, but less satisfactory and rougher, method for estimating the inter-pupillary distance, when the adjustable trial-frame and cross-line glasses are not available. The patient is placed at full arm's length away, looking steadily at the centre of the observer's forehead. A short millimetre rule is then laid horizontally across the patient's face, resting on the bridge of the nose. One end of it is held exactly in front of the *inner* edge of the cornea of the patient's right eye, and the position on the scale where the *outer* edge of the cornea of the other (left) eye intersects behind it, indicates the inter-pupillary distance. The left eye of the observer is used to note the end of the rule opposite the right eye of the patient, and the observer's other (right) eye takes the measurement shown opposite the patient's left one. It should, however, be the

exception, and never the custom, to employ this method, as entire dependence cannot be placed upon its accuracy.

Before describing the methods for correcting errors of refraction with lenses, there are a few points about the inner mechanism of the eye that require a moment's consideration.

The function of the zone, or circle, of ciliary muscle within the eye, is, during its contraction, to indirectly relax the lens; so that it expands in thickness from before backwards, and becomes thereby more convex. This alteration in shape necessarily shortens the focal distance for rays of light that enter the eye. Therefore, when the eye is a hypermetropic one there is this natural means by which it can, to some extent, be compensated.

The inherent elastic property of the lens is greatest during early life; it diminishes gradually with the progress of years, until at the age of sixty it has altogether disappeared. Therefore the amount of hypermetropia that a patient is able to correct unconsciously in this manner, is a gradually diminishing factor as life advances, and finally is altogether lost. It thus becomes necessary to supplement it artificially by the aid of glasses.

The total hypermetropia (H.t.) present in an eye can be divided into two portions: these are in constantly and regularly varying ratio to each other, one decreasing whilst the other increases, in accordance with the person's age. The one portion of it is not apparent, because of being compensated naturally by the lens; this is known as Latent Hypermetropia (H.l.), and it is this portion that

gradually decreases as the individual grows older. The remaining portion, known as Manifest Hypermetropia (H.m.), is readily detected when the vision is being tested: its gradual increase is closely associated with the progressive diminution in the general visual acuity of the case. The sum of these two portions together forms the Total Hypermetropia.

To give an example of this:—In a child, ten years old, with the total hypermetropia equivalent to that which is corrected by a convex (plus) lens of 5 dioptres, all of it at that early age might be compensated by the natural power in the lens: therefore all of it would be latent then, and none of it manifest, and the vision might be $\frac{6}{6}$ (normal). At the age of forty in the same individual, perhaps 3 dioptres of this hypermetropia might have become manifest, and the remainder—reduced in amount—still be latent. In consequence, the visual acuity might have possibly become diminished to $\frac{6}{9}$; but with a convex lens of 3 D. spherical—the measure here of H.m.,—the vision would regain its original standard of $\frac{6}{6}$. This would be expressed in writing thus:—

$$\text{V. } \tfrac{6}{9}. \quad \text{H.m. } 3\text{ D.} = \tfrac{6}{6}.$$

These relative proportions would be still further modified as the age advanced; until at sixty, the whole 5 dioptres of the hypermetropia in this case would have become manifest. By natural inference it can be understood that in exact ratio as the Manifest hypermetropia increases, exactly so much does the Latent hypermetropia decrease; whilst the Total hypermetropia remains unchanged. The method of judging these several proportions will be described presently.

The accompanying table explains this example more clearly:—

Age (in years).	H.m.	H.l.	H.t.
10	Nil.	5 D.	= 5 D.
20	1 D.	4 D.	= 5 D.
30	2 D.	3 D.	= 5 D.
40	3 D.	2 D.	= 5 D.
50	4 D.	1 D.	= 5 D.
60	5 D.	Nil.	= 5 D.

Exactly the same apparently progressive increase is evident, and in almost equal measure, in those cases where there is astigmatism. During early years its existence may escape detection altogether. Later on, the lens can no longer be adapted (by the action of the ciliary muscle) to compensate the distortion in the visual impression of outward objects, which would otherwise take place; and its effort to do so becomes a gradually increasing strain, which ultimately produces the harmful secondary symptoms to which reference has already been made.

Patients not unfrequently imagine that the astigmatism, which may only begin to prove troublesome towards middle life, is a new condition: whereas the fact is, merely, that up to that time they have inherently been able to overcome it, and therefore its existence has been unobserved.

In connection with this same elastic property of the lens there is one further point to be considered. When an eye, in its natural position of rest, has been directed towards some distant object, and then suddenly engages in the act of reading, the focus of

the lens becomes changed or shortened accordingly. This is equivalent to the increase in its dioptric strength of 3 dioptres (+ 3 D. spher.). This alteration is actuated similarly by the mechanism of the ciliary muscle; and associated with it there is contraction in the size of the pupil, though this latter does not affect the present question. The whole combined action is referred to as the **Act, or Power, of Accommodation.**

The lens, as age increases, loses its elasticity; and the time arrives when this property of adaptation in it for reading becomes gradually less effectual; until at last, at the age of sixty, it has entirely disappeared. The evidence of this change, usually first noticed about the age of forty, is commonly described as **Presbyopia.** In its early stages the individual, in order to see clearly, begins to hold reading matter, or other near objects, further away from the eyes than is customary; and as time goes on objects are held still further away. The result is that, by the well-known law of inverse squares, the intensity of illumination on the object is lowered, and it appears smaller and less distinct. In the effort to minimise this effect, print which is darker and also larger is selected; or possibly complaint is made about the inferiority of illumination, and there is resort to some other stronger source of artificial lighting, or perhaps daylight alone may be used for reading.

The progress in this physiological change that occurs in the lens, is marked by the loss of power of half a dioptre (+ 0.5 D.), approximately, at forty years old; and a similar amount for each successive period of four years, until the age of sixty is attained.

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In order to compensate this and maintain the eye at its normal standard for near vision, or ability to focus for reading at the usual distance of 12 inches, convex glasses must be provided at a corresponding rate of increase.

This correction for Presbyopia, however, must always be over and above any other that is required, either for hypermetropia or astigmatism; and therefore the strength of any glasses so ordered for reading, must be in addition to, or combined with, the other glasses used for distance. If no correction is needed at all for distance, the reading glasses of appropriate strength would be prescribed alone for near-work.

Table of Average Correction for Presbyopia

Years.	*Dioptres.*
40	+0.5
42	+0.75
44	+1
46	+1.25
48	+1.5
50	+1.75
52	+2
54	+2.25
56	+2.5
58	+2.75
60	+3

CHAPTER II

EXAMINATION OF THE VISION

THE acuity of vision is measured by the use of a set of printed types, arranged on a board in lines, of graduated standard sizes. This is placed at a distance of 6 metres (or 20 feet) away from the person whose eyes are being tested: the precaution must be taken that the source of light falling on the board is not directly in front of the eyes, but placed to one side so that it does not dazzle them. The largest of the letters, which is usually at the top of the test-board, is equivalent in size to one that can be read by the normal eye if at a distance of 60 metres (200 feet) from it: the letters next proportionately smaller, on the line below it, are so seen at 36 metres: the line below that again, at 24 metres: then 18, 12, 9, 6, and 5 metres. All these lines of letters, if placed at the respective distances from a normal eye which their registering numbers represent, would all approximately appear of the same size. Not only is the total size of letter thus calculated, but its thickness of outline is also so graduated. Snellen's arrangement of these types is that most commonly employed.

For those who are illiterate, various forms and signs have been devised; these are similarly arranged in graduated sizes on a test-board.[1]

[1] See Note in Appendix.

As has just been stated, the usual distance at which the sight is tested is 6 metres: accordingly, when the individual is able—reading with each eye separately whilst the other one is occluded—to discern the line marked D. = 6, vision is held to be normal, and is expressed as V. = $\frac{6}{6}$. If, moreover, the eye can also read the line below it easily—the 5-metre line, at the distance of 6 metres, the vision is above normal, and is written as V. = $\frac{6}{5}$. But if, for example, the eye can only see the large letter at the top of the board, that is marked D. = 60, Vision = $\frac{6}{60}$.

The lowest line, or the line with the smallest size of letters that can be read, always forms the *denominator* of the fraction that is used to express the visual acuity; and the distance that separates the patient from the test-board is indicated by the *numerator* of the same fraction. When the top letter cannot be read at 6 metres, but is seen if the patient is brought nearer to it (for example, to within 4 metres), the vision is then said to be $\frac{4}{60}$ of the normal; and if not read until within 1 metre of it, V. = $\frac{1}{60}$.

If the defect in Vision is still greater, it is then tested by the ability of the patient to Count the fingers held in front of a dark background, like the observer's coat. The furthest distance away that this can be done is recorded; *i.e.* V. = Counts fingers at . . . . . If vision is still less, it is tested by the distance at which simple Hand-movement can be distinguished. Then follows the distance for the mere Perception of light, which is usually thrown on the eye from the mirror of an ophthalmoscope. This is the limit; after which it is

described as No perception of light, or Total blindness.

Although the foregoing tests are made in the first place when the patient is without correcting glasses, precisely the same procedure is followed when they are worn. Each eye should be tested separately; and in occluding the other eye care must be taken not to exert any pressure on it. It is advisable to make a practice of methodically testing them in a definite rotation, always beginning with the same one, either the right or left eye, as this avoids the possibility of any confusion subsequently.

In this systematic testing of the patient the visual acuity is first ascertained with the eyes in their position of rest and free from all effort of accommodation, as when looking at "infinity"; this, in practice, as already mentioned, occurs when the test-board is placed at a distance of 6 metres away. The lowest line then distinguished by each eye separately, is noted: if only a portion of the line can be read, it is also duly recorded by placing the numbers of the letters, so seen, in brackets after the fraction, thus: *e.g.* V. $= \frac{6}{9}$ (3 l.), meaning that only three letters of the line are seen.

Whatever the visual acuity may be—either the $\frac{6}{6}$-line, or one of the lines of larger type above it, the correct routine practice is to place a spherical convex lens of 1 dioptre (+1 D. spher.) before each eye, in turn, in the trial-frame. Then, if the clearness with which the letters first seen remains exactly the same, or is even improved, the lens is changed for successively stronger ones, until some impairment becomes evident: the last lens to afford perfectly clear vision indicates the limit of the

manifest hypermetropia. An example of this would be written thus: V. $\frac{6}{12}$ H.m. 2 D. $=\frac{6}{6}$. In hypermetropia it is always the *strongest* lens that still allows the letters to be seen with fullest clearness, that indicates the amount of manifest hypermetropia present in the case.

If, however, the vision cannot be improved to normal by this means, and attains perhaps only to $\frac{6}{12}$ possibly, other more extended investigation, which will be described later, must be employed to disclose the cause; and this, very frequently, proves to be astigmatism.

In the case where vision is $\frac{6}{6}$ and a convex lens of even a fraction of a dioptre impairs it, this may be regarded as Emmetropia. But even in this case, if there is a history of headaches or similar trouble, there may be, nevertheless, some error latent—as astigmatism, or ciliary spasm perhaps, which other examination would reveal.

If, however, no improvement, but the reverse, is produced by even the weakest of the convex lenses, it is then, and only then, that a concave or minus lens may be employed in testing. If improvement results, the case is one of Myopia; and it is the *weakest* concave lens with which the $\frac{6}{6}$-line can be read, or the nearest approach to that standard is obtained, which indicates the degree of Myopia present. An example of this might be written: V. $\frac{6}{12}$ M. 2 D. $=\frac{6}{6}$.

As in hypermetropia, so here too, where there is failure to read the $\frac{6}{6}$-line, further investigation must always be made to ascertain the cause, in order that the attempt may be made to remedy it.

There are, of course, other causes than astigmatism

accountable for defective vision which cannot be corrected to $\frac{6}{6}$. These are irregularity or opacity of the cornea; changes in other media, or in the fundus; also it may be secondary to some morbid condition or change in the body. All these will be referred to later.

When vision has been tested for distance, the appearance of the pupils, and other similar particulars comprised under external examination, are to be noted; also the freedom or limitation of movement in various directions of the globe under muscular action.

The power of reading is next tested. The usual distance for this is 30 cm. or 12 inches, and the patient is asked to read the special part of the test-card relating to this distance. The result of this is then recorded: it must be specially noted whether possibly only larger print can be seen there, or whether it has to be brought nearer to the eyes. The reading test should never be made alone, but must always be in conjunction with, or supplementary to, the examination of the distant vision.

When the vision does not attain to normal, and there is no apparent pathological cause evident to explain the defect in it, the examination, which so far has been a subjective one, must now be made objective.

CHAPTER III

OBJECTIVE EXAMINING TEST

THE most reliable and accurate method for this purpose is that which is generally known as Retinoscopy, or by some is called Skiascopy; and in every case where there are persistent or recurring headaches associated with the use of the eyes, this further method of examination should always be followed.

The ciliary muscle must be fully relaxed, and unless there is special contra-indication, it is temporarily paralysed by means of a mydriatic.

Before instilling any mydriatic drug for this purpose, it should be a regular custom to examine the tension of the globe, in case it may prove to be increased; which would then naturally deter use of the drops, fearing that it might induce an attack of glaucoma: the fundus of the eye should also be previously examined with the ophthalmoscope.

When thus testing the tension of the eye the patient is told to look downwards at the ground, and the eyeball is palpated gently with the tips of the two forefingers resting on the skin of the upper lid. The tension of the one eye is compared with the other; or with that of the eyes of the observer, if there is any doubt. This pressure must always be exerted gently, and made from above down-

wards; so that the bony plate of the orbital floor constitutes the firm medium of resistance. Were the palpation exerted from before backwards, the fatty tissue, lying within the orbit and behind the globe, forms such an elastic cushion or medium that it would only give a misleading and useless result.

In young children the power of accommodation is very considerable, and it is necessary to employ a solution of Atropine sulphate of $\frac{1}{2}$ per cent. strength (grs. 2 to ℥i): one drop is instilled, morning and evening, inside each lower eyelid for three days, up to and including the morning of the examination. The effect persists for about three weeks before it has entirely passed off.

The action of Hyoscin (Scopolamine), in solution of similar $\frac{1}{2}$ per cent. strength, is equally efficacious in the generality of cases where the children are older—between ten and sixteen years. It is best used in the form of Hydrobromide; and whilst its action is more speedy, often permitting of the eye being examined within an hour after a single instillation, it offers the special advantage that its effects disappear again more quickly than those of atropine, usually in about ten days. In many children, however, the stronger effect of atropine is found necessary.

Beyond the age of sixteen, a less powerful mydriatic suffices; and a solution of Homatropine hydrobromide and Cocaine hydrochlorate in combination together, each in 2 per cent. strength, is quite reliable, and produces full ciliary relaxation in about forty minutes. Its effects disappear much more quickly, usually within twenty-four to forty-eight hours.

After the age of fifty-five, when the question of the presence of accommodation becomes negligible,

it is found that a simple 4 per cent. solution of Cocaine hydrochlorate is enough—if any artificial aid is then required for the purpose. At that period of life, however, unless the error of refraction is a complicated one, it is usually quite possible to correctly determine its nature by means of the examination at the test-board alone.

Where a mydriatic has been used in any case over fifty years old, a drop of Eserine should be instilled when the examination is completed, in order to avoid the occasional risk of onset of an attack of glaucoma following on dilatation of the pupil. Eserine salicylate may be used for this in $\frac{1}{2}$ per cent. strength.

The various drops enumerated here can be kept indefinitely for long periods and without deterioration in any climate, if made with a saturated solution of Boric acid instead of distilled water; and if the precaution is also taken to avoid contamination when using the dropper.

It is to be strictly observed that in any patient over sixteen years old, atropine ought not to be used as a preparation for the retinoscopy examination. It is wrong to do so, because of the long enforced interruption that ensues before full visual function is restored; and it is more than thoughtless, and in a sense almost culpable, to use it for the mere dilatation of the pupil in the daily wage-earner. Neither has the use of a myotic—whether eserine or other preparation—any appreciable effect in counteracting the local paralytic action afterwards, or in shortening the unnecessarily long period of idleness, before the patient can see sufficiently to return to work again.

A small mirror, with a central aperture, is all

that is specially needed for this examination by retinoscopy: the mirror is preferably a concave one, equivalent in strength to 1 dioptre.

The principle of Retinoscopy depends on the fact that when the reflection of a light is made to travel across the patient's face, the interior of the eye, as seen through the pupil, is momentarily lit with a bright glow; and it is the direction in which this glow disappears again, that serves as the indication by which the degree of refraction, and any error in it, is estimated.

Although it is the glow seen in the eye that actually furnishes the indication or guide, it is the shadow immediately following it and replacing it, which is usually made to serve the same purpose; as it is more easily observed, and is therefore more commonly used in any description.

The light falling on the patient's face travels synchronously with the movement of the mirror: consequently, the glow already referred to, and likewise the shadow that replaces it, is seen to appear and disappear again as the light passes across the eye. In some cases this shadow is seen to apparently move in a direction *contrary* to that of the mirror; this occurs when the refraction of the eye is normal (Emmetropic); also when it is Hypermetropic. In Myopia the glow, and the shadow following it, move along *with*, or in the same direction as, the mirror.

The foregoing applies solely to the use of the concave mirror for Retinoscopy, and will be adopted in the descriptions here throughout.

When a special retinoscopy mirror is not available,

the ordinary concave one of the ophthalmoscope forms a serviceable substitute.

If a plane or flat mirror is preferred instead, a converse appearance is seen; the glow and shadow then move *with* the mirror in both Emmetropia and Hypermetropia, and *against* the direction of the mirror in Myopia. But as the concave mirror yields an appearance in the eye that is more sharply defined, and therefore easier of interpretation, it is more generally used than the plane one.

The room used for the examination should be darkened, and a lamp placed near the side of the patient's head, just behind the level of the face: the latter is kept in shadow by a small screen affixed to the lamp, and which shields off the heat. The observer sits rather more than a full arm's length away, and looks through the aperture of the mirror, which is held close in front of the right eye. The lamplight is then reflected on to the patient's face, and, by a gentle rocking motion imparted to the mirror, is made to travel to and fro across the eye there—first in horizontal and then in vertical direction. The least fatiguing position for the observer is to hold the mirror between the fingers, with the handle pointing vertically downwards, whilst the forearm flexed on the upper arm is kept against the chest.

The spectacle trial-frame is placed on the face and the inter-pupillary distance ascertained. One eye is then occluded with the obturator, and—presuming that the shadow moves contrary to the mirror—convex or plus glasses are interposed before the eye under examination, in increasing strength, until a lens is found that changes the direction of the shadow

movement, so that it travels with the mirror—as it would do in Myopia. It is the *last* lens that still preserves the 'contrary' motion unchanged, which indicates the degree of error. When this has been ascertained in one meridian of the eye, exactly the same procedure is repeated in the meridian that is at right angles to it. This applies to Hypermetropia.

For example, if a convex lens of 4 dioptres (+4 D. spher.) is the first one to reverse the shadow and cause it to move with the mirror, the hypermetropia would be noted as equivalent to + 3.75 D.; as this is the next lens, or fraction of lens, below it in degree in the numerical scale.

In Myopia (where the shadow moves with the mirror), successively stronger concave or minus lenses are similarly placed in the trial-frame, until the shadow begins to move in the contrary direction; and it is the *first* lens to produce this alteration that indicates the degree of myopia.

If, for example, a concave lens of 6 dioptres (– 6 D. spher.) is the first to produce this effect, the myopia is noted as being of the degree represented by that lens, namely, – 6 D.

Accordingly, in *all* instances, the lens that serves to indicate the degree of error is that one which, when the shadow is on the verge of changing direction, is associated with the appearance in the shadow-movement that is *contrary* to that of the mirror. This, which is equivalent to a state of emmetropia, indicates that the existing error has been eliminated by the lenses placed before the eye in the trial-frame.

In order to make use of the information derived by this means, it is necessary to recall the fact that the concave mirror used for the examination

represents a strength of 1 dioptre (+1 D. spher.). When the final calculation of error is ultimately made, that amount is deducted from the findings of the retinoscopy, and therefore so far modifies them.

In the example just now given of hypermetropic error, which was recorded as +3.75 D., it would in actuality be +2.75 D. spher.; and in the example of myopia given, the −6 D. spher., for similar reason, becomes −7 D. spher.

If the use of the plane mirror is preferred, no after-calculation is required; as it is the strongest convex lens that still preserves the hypermetropic movement before it is reversed, that indicates the amount of error there; and in myopia it is the weakest concave glass first producing the hypermetropic movement, that indicates its measure.

It will now readily be understood—speaking again of the use of the concave mirror—that in low degrees of error, where the contrary-shadow is found equivalent to a lens of +1 D. spher., the case—when that amount is deducted on account of the mirror, is proved to be one of emmetropia, which occupies the position of zero in the scale of lenses.

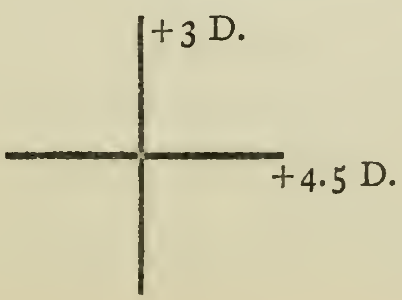
Similarly, if the contrary-shadow represents a still lower lens (+0.25 D. spher., for example), the case, when deduction for the mirror is made, is found to be one of myopia equivalent to an error of −0.75 D. spher.; this is the lens one dioptre lower down in position in the numerical scale below +0.25 D. (*see* page 6).

In order to avoid possibility of confusion when testing the case subsequently, the notes of the retinoscopy are written down precisely as found; and the necessary modifications are made later at

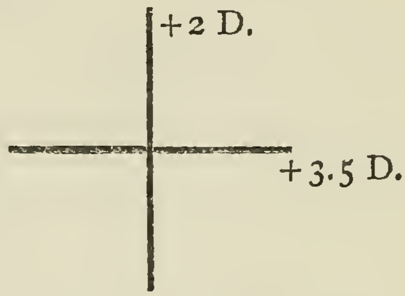
the time of further testing when the examination is completed.

These two meridians in each eye, derived from the examination by retinoscopy, whilst practically always at right angles to each other, are not necessarily horizontal and vertical, as they may be placed at any degree of inclination. It frequently occurs that the observer, in rocking the mirror, notices that the shadow does not follow it exactly, but moves along a different meridian, at some inclination between the vertical and horizontal. It is incumbent then to let the mirror follow this meridian in the direction of least resistance, and having examined it, to investigate the meridian at right angles to it.

When both meridians show the same degree of refraction, the error, if present, is a spherical one. The two meridians are, however, frequently of dissimilar strength or degree of error; and it is the difference which exists between these two meridians that constitutes the amount of astigmatism or astigmatic error in the case. This, when present, always forms a relative and unvarying quantity in the calculations. Accordingly, when deduction is afterwards made on account of the mirror, the amount of astigmatic error still remains unchanged; as it is the spherical portion of the correction, forming the basis of the error or correction needed, that undergoes modification. The following is an example:—



This result, given here, of examination with the concave mirror, represents + 3 D. spher. combined with + 1.5 D. cyl., with axis vertical, or 90°. Now deducting 1 dioptre all round for the mirror, it becomes 2 D. spher., and is still combined with + 1.5 D. cyl. This may be more clearly evident if written out in the same form; after the deduction it would become:—



The easiest method to follow is first to estimate the amount of astigmatism in the formula before making any deduction, and then simply subtract 1 dioptre for the mirror from the *lower* in value of the two meridians. This applies equally in every case, whether it is hypermetropic or myopic astigmatism.

When the retinoscopy examination has disclosed the existence of astigmatism, it is easy, and always advisable, by a small further step to ascertain the degree of the inclination of axis in the cylindrical lens. At the same time, this also acts as a useful check on the correctness of the original finding.

The method is as follows:—A spherical lens that is equivalent to the lower degree of error, and a cylindrical lens representing the amount of astigmatism, are placed together in the trial-frame: then, when the cylindrical lens is in its proper position, the light from the mirror can be made to travel in any direction, along any meridian,

and always elicit the same uniform appearance of movement. When this result is attained it proves that the position of the cylindrical lens in the trial-frame is so correct that the astigmatic error has been eliminated, and a condition of simple emmetropia replaces it. It will now be found that if the cylinder is rotated slightly to one or other side, the result is disturbed and produces confusion of movement in response to the mirror, instead of clear movement in one or other direction. Likewise, if there has been an error made in estimating one of the meridians in the first place, it will become clearly apparent by this supplementary test. The point on the trial-frame against which the axis-mark of the cylindrical lens rests, is then to be recorded; but in no case must this be regarded as absolutely correct until verified by the subsequent subjective control-examination with the test-board, which is always necessary.

As this proves such a valuable detail in the conduct of the retinoscopy examination by serving as a double control, it is one that should never be omitted.

In order to be perfectly sure of the absence of mistake, it is best to make one further concluding step in this examination. Both the spherical and cylindrical correcting lenses being in proper place in the trial-frame, the spherical portion of the error is over-corrected by the addition of the lowest convex lens (+0.12 D. spher.). This should distinctly reverse the direction of shadow movement, in all meridians equally and at the same time.

When working out the error of refraction by retinoscopy, the estimation should be made within

$\frac{1}{8}$ of a dioptre (0.12 D.) in both meridians. This is especially useful when astigmatism exists; and as most modern trial-cases contain this subdivision of lenses in their lower powers, it can always be added in combination in the trial-frame with higher lenses, when they are used. Very many patients are able to fully appreciate the difference which this makes in their vision.

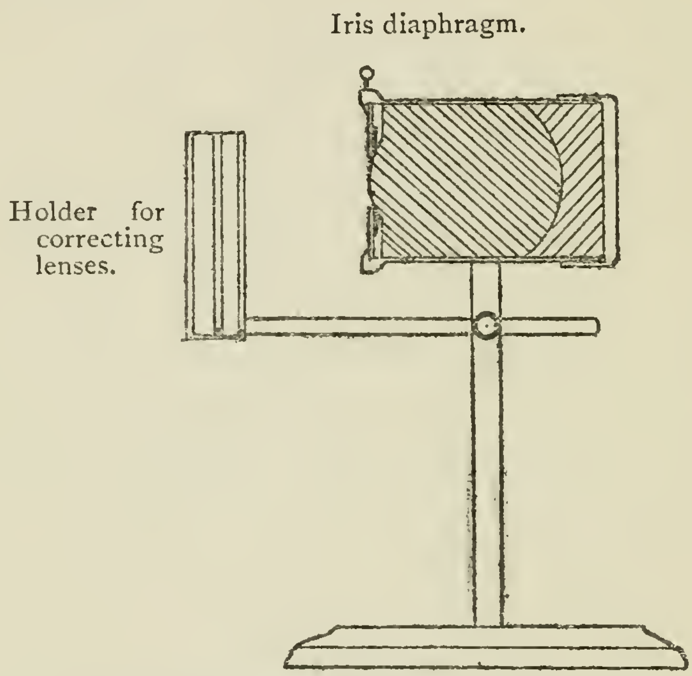


FIG. 5.—Ryland's schematic eye (section).

When the observer is estimating the point of reversal in testing with the shadow movement, the most convenient and practical method is to boldly go beyond it, by placing in the trial-frame the lens which distinctly exceeds the desired effect, and thus over-corrects the error; then by working backwards, and changing gradually to weaker lenses, the original appearance is reproduced again, and the precise point of delimitation can be defined.

It requires the experience only to be gained by practice, to determine quite the precise point at

which the shadow movement can be deemed to have changed, so that it moves in the reverse manner to its original direction. There are Model Eyes made for the purpose of practising this (Figs. 5 and 6).

In this the object should always be to determine the extreme limit of 'contrary' movement in the shadow. Accordingly, if the case is one of hypermetropia, the successive lenses are changed

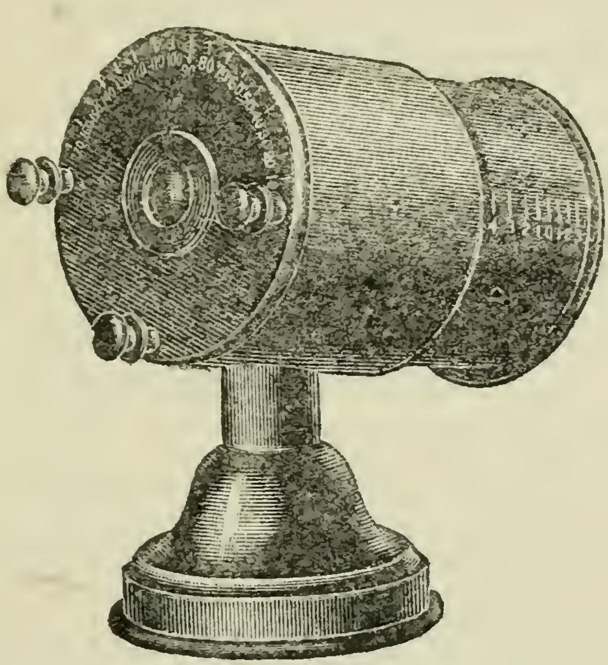


FIG. 6.—The Thorington model eye.

until just the faintest remaining flicker of dark shadow can be detected still, appearing in the pupil on the side opposite to that on which the mirror-light enters it, before it moves across. Then by one further change to the next stronger numerical power in the series, this shadow ought to move with the mirror; but if it can be reversed once more by the insertion of a -0.12 D. (concave) spherical lens, which deducts that amount from the total lens strength, this shows that it has reached the exact limit. Thus, to take a fuller example :—The shadow

moving originally across the dilated pupil against the direction of the mirror; and the last lens interposed, before it moves the other way, in this instance is $+2.25$ D.; then by the addition to it of $+0.12$ D. spher., the shadow is seen to distinctly move with the mirror; but by removing this extra lens the original appearance is again produced. The $+2.25$ D. would therefore be the correct measure of the hypermetropia recorded in that meridian.

Quite similarly, if the case is one of myopia, and -4 D., as an example, is the first lens that changes the direction of the shadow so that it moves against the mirror; the addition now of $+0.12$ D. spher. to it (which deducts from its strength) is found to bring back the original appearance again: therefore -4 D. is the measurement here of the myopia in that meridian.

It should be a habit to pass each lens lightly through a cloth or leather in the hand, in order to clean it before placing it in the trial-frame; otherwise the accidental cloudiness, derived from handling the lenses, is apt to obscure the effect that is looked for.

In the dark-room when changing the lenses for retinoscopy, it is economy of both effort and time to adopt some regular method of doing so. Beginning, for example, boldly with a lens of 3 dioptres, this may prove insufficient; the next one taken to replace it would be 5 dioptres; and afterwards 7 dioptres if need be, and so on; and always systematically returning to the lens midway in position, if the effect is overstrong. If in the first place the lens of 3 D. is too strong, that chosen to succeed it would be 1 dioptre. These steps of sub-

division of the power are continued on the same principle, backwards and forwards, until the exact result is obtained. It would be found both slow and tedious were the lenses progressively changed in absolute consecutive scale or series, continuously one after the other.

The gaze of the patient remains, throughout, directed towards the centre of the observer's mirror. The measurement is thus made from the macula or yellow spot, as that alone is of any value for visual purposes in this examination.

The state of the refraction as ascertained by retinoscopy, is the optical measurement of the eye when its parts are relaxed completely, or in a condition of rest; this permits of minute accuracy in the investigation. But in ordinary circumstances, except during sleep, the eye is scarcely ever at rest, even for a moment. The lens, as well as the pupil-aperture, undergo incessant alterations both in size and shape, in response to modification in the focus of the eye, as throughout the day it is directed in looking from one object to another. It is to be remembered that it is under these latter conditions the eye requires the assistance it derives from lenses; and the data supplied by the retinoscopy test ought therefore to be strictly regarded as only the basis on which the further testing of the eye is to be continued. It should never be accepted alone as sufficient guidance for prescribing spectacles, without taking opportunity to test the individual when the effects of the mydriatic have passed off.

The sole exception to this last statement is in the case of quite young children who are still

illiterate, or practically so; or in those who perhaps lack intelligence. Very little real dependence can be placed on the accuracy of results obtained by any subjective examination of their visual acuity, when it is done with the test-board—even although other signs are substituted for the usual letters. In these cases it is of greater service to base the estimate of the visual acuity, and its requirements, simply on the findings derived from careful examination by retinoscopy.

Before employing the retinoscopy data for further examining the vision, there are certain points that require some modification. Where the concave form of mirror has been employed, it is necessary to deduct $+1$ D. from the figures recorded; this is in allowance for the power which it represents. Apart from this, in cases of hypermetropia below middle age, the innate effort of accommodation usually demands some further deduction as well. In children it is often necessary to subtract as much as $+2$, or even $+2.5$ D., in respect of this, before clear vision of $\frac{6}{6}$ can be obtained with comfort to the patient. As a person's age advances, this allowance becomes gradually less; until between fifty and sixty years old, scarcely any allowance is needed; and later, none at all.

When the case is one of myopia in either young or older subjects, the question of this allowance for accommodation is much slighter; but even here it varies, and each case is to be regarded on its own merits separately.

Whenever astigmatism forms part of the error, the effort should be always made to correct it fully when

ordering spectacles. But in elderly people, and even, too, in some young adults, where the error has not been previously detected, it is not unusual to find in practice that greater comfort is obtained in the eye, and with equally good visual acuity, by somewhat under-correcting it. Later on, when more accustomed to the improved conditions and the relief from strain which the glasses afford, the wearer may be able to accept the full astigmatic correction, and so abolish all strain on the eye with its reflex consequences.

Furthermore, whilst it is found that the axis of the astigmatic error, as a general rule, approximates closely to the position ascertained by the retinoscopy, this is not always so. Here again it is in those of more mature years and previously unaccustomed to the use of glasses, that such difficulties most often occur. The fact may be explained by the supposition that the eye has hitherto unconsciously endeavoured to overcome the distortion of the retinal image, due to the astigmatism, by the exertion of muscular (ciliary) action; and that the eye, in consequence, becomes accustomed or set to this; and some considerable time may elapse before this acquired habit disappears. In children, as might be expected, this does not occur to any appreciable extent.

In cases during adolescence and the years following, when there is difficulty in obtaining satisfactory vision at the test-board, it will be found that the condition is not unfrequently due to some spasm of the ciliary muscle within the eye, associated with a general asthenic state; or it may be to persistence of a previously established and incorrect

habit, acquired by the eye in its unconscious effort to overcome the astigmatism.

An efficient means to adopt is the instillation of a very dilute solution of a mydriatic to act as a cycloplegic. A collyrium recommended for this purpose is 6 minims of atropine solution, (4 grains to 1 ounce in strength,) added to 1 ounce of saturated solution of boric acid. One drop in each eye is enough, inside the outer corner of the lower eyelid, at bedtime. The effect of this is to gradually relax any degree of spasm present, and at the same time does not interfere with the power of reading or accommodation. These drops should be continued for a period of two to three weeks, being used at regular, separated intervals, two nights in the week. It is perhaps needless to say that the tension of the globe should be kept under observation, in case of any pre-existing tendency towards its increase.

It is usually found on re-testing the eye that the previous difficulty has disappeared, and that it is able to accept now a closer approach to the measure of correction, as indicated by the retinoscopy examination which was originally made.

In children up to about the age of ten, and who are old enough to be tested with letters, it is not always advisable—more especially when there is much hypermetropic error, or astigmatism with it, or when there is a squint—to allow the effect of the mydriatic to pass off before the glasses are actually begun to be worn. Otherwise, in a majority of cases, it is found that some measure of ciliary spasm returns, and the eye declines to accept its proper correction, either in respect to the power of lens or

the inclination of the cylindrical axis. In these the mydriatic should even be continued, but perhaps at slightly longer intervals, until the glasses are ready to wear. Therefore when, as is most usual, atropine is used, practically three weeks elapse before the eye becomes normal; so there is sufficient time for the eye to become gradually accustomed to the newer conditions, which makes the transition stage an easier one.

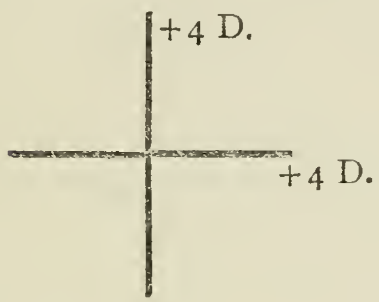
These children last mentioned are probably quite intelligent enough to answer correctly when tested with the letters on the board; but the dilated pupil makes any attempt at focusing seem impossible. This difficulty is very simply overcome. A thin metal obturator disc is used, the same size as the trial lenses, with both of its surfaces blackened, and with a round central aperture 3 mm. in diameter: it is convenient to have a pair of them. It is used in the trial-frame, slipped in behind the lenses that are before the eye; and by acting as substitute there for the iris and pupil which are dilated, it improves the definition of the visual sense.

It is always advisable to revise the examination of the eyes about every two years in cases of young children; and in those older, but who are still in the active stage of growth and development, at somewhat longer intervals. By this means advantage is taken of any improvement in the shape of the globe to suitably modify the glasses that are being worn.

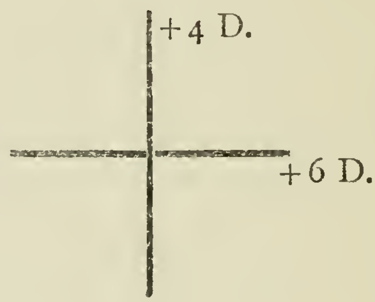
The retinoscopy examination having been completed, it will now be useful to work through the further testing of a suppositious case in detail.

In the first instance the inter-pupillary distance is to be examined afresh, as it is not unusual to find a difference in this when the eyes are under a mydriatic effect, and when they have resumed their natural state. The measure thus obtained must be increased by 2 mm., in allowance for the altered position of the eyes which, now that the mydriatic has passed off, are first tested for distance (*see* page 20).

Let it now be assumed that the result of the retinoscopy shows :—



R.E.



L.E.

When 1 dioptre for the mirror, and possibly 1.5 dioptre further for the accommodation, have been deducted, the formula reads as :—

$$\text{R.E. } +1.5 \text{ D. spher.} \qquad \text{L.E. } \frac{+1.5 \text{ D. spher.}}{+2 \text{ D. cyl., axis } 90^\circ.}$$

This latter formula is a reminder that the amount of the astigmatism is first calculated ; and then the two deductions mentioned above are made from, the *lower* of the two numbers in the original formula, as that represents the spherical portion of the error. The cylindrical correction for the astigmatism, being a purely relative measurement, remains unchanged. As previously stated, any change made in the lower of the two figures in the retinoscopy formula, must

similarly affect the higher of the figures in an equal degree.

No such calculation may be arbitrarily accepted without proper verification. Therefore the eyes must be again submitted to subjective examination after the mydriatic has completely passed off, using these data supplied by the retinoscopy as the basis or guide.

The lens or lenses, in accordance with the formula which has been modified as above, are placed in the trial-frame. A low-power convex spherical lens (or concave, as the case may be) is then interposed in front of them to discover whether vision is thus improved, and any necessary alteration is accordingly made. This is repeated again and again, until the best satisfactory visual result is finally attained. This last detail, when astigmatism is present, is tested not only with the chart showing radiating lines, or printed with variously inclined strokes in the shape of letters, but also with the smaller ordinary lines of letters on the ordinary distance test-board.

If, with the foregoing revised formula, vision attains to $\frac{6}{6}$, this might possibly represent the spectacles ordered for distance. But if only necessary to order them for reading, the frame would be required to be made with a difference of 6 mm. narrower in the measurement of the inter-pupillary distance. Accordingly, if on retinoscopy examination the P.d. is 62 mm., the P.d. for distance would become 64 mm., whilst that for reading would be 58 mm. (*see* page 61).

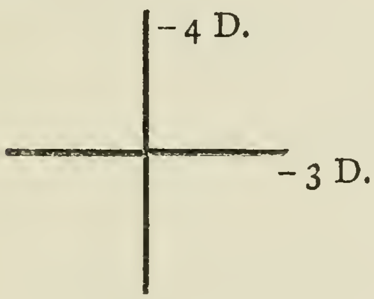
When the age arrives for presbyopic correction, it is added to the lower, or spherical portion of the

formula, whilst the figure of the cylindrical correction remains throughout unchanged. In this instance, if 1 dioptre is needed for the presbyopia, the formula of the reading-glasses becomes :—

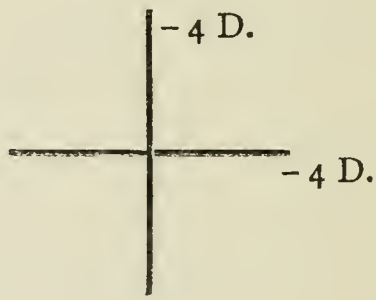
$$\text{R.E.}\ +2.5\ \text{D. spher.} \qquad \text{L.E.}\ \frac{+2.5\ \text{D. spher.}}{+2\ \text{D. cyl., axis } 90^\circ.}$$

When distance-glasses alone are used, the correction for presbyopia would be based on them. When there are special spectacles for reading, this correction is invariably added to them instead.

In Myopia the procedure for prescribing spectacles is exactly the same, and may be exemplified as follows :—



R.E.



L.E.

This, literally transcribed, would be :—

$$\text{R.E.}\ \frac{-3\ \text{D. spher.}}{-1\ \text{D. cyl., axis } 180^\circ.} \qquad \text{L.E.}\ -4\ \text{D. spher.}$$

The deduction of + 1 D., on account of the mirror, from the spherical factor, is equivalent to passing lower down the scale of lenses; and consequently the concave or minus lens of 3 D. spher. would become − 4 D. spher.; whilst the cylinder, being merely a relative quantity, remains numerically the same—in this instance 1 dioptre beyond the spherical error. The lens for the left eye, in similar manner, becomes − 5 D. spher. The further

modification of the formula to allow for the power of accommodation, can only be ascertained by actual testing, because that is a variable and uncertain quantity, and more especially so in myopia.

Here, therefore, for the attainment of a $\frac{6}{6}$ standard of vision, the formula for the glasses might be :—

R.E. $\dfrac{-4 \text{ D. spher.}}{-1 \text{ D. cyl., axis } 180°.}$ L.E. -5 D. spher.

It is possible, however, in allowance for the existence of some accommodation, that these glasses might have to be made still more strongly concave. In myopia, it is the weakest concave spherical lens yielding $\frac{6}{6}$, or whatever the best visual result may be, that is the one prescribed ; and always most carefully avoiding any lens that exceeds beyond it. The patient, through inexperience, might perhaps be apt to imagine that a lens which is really too strong, seems an actually better one ; but inquiry proves to the observer that the letters on the test-board, though said to be seen more clearly, simply appear smaller and blacker, and are more sharply defined. This is due to over-correction and is to be avoided.

In myopia the glasses ordered for distance should be constantly worn, except whilst engaged in reading or other near-work. The lenses for the latter, following the common rule mentioned elsewhere, would be 3 dioptres more convex, which is the same as 3 dioptres less concave. Therefore the glasses for reading, in the case just cited above, would be :—

R.E. $\dfrac{-1 \text{ D. spher.}}{-1 \text{ D. cyl., axis } 180°.}$ L.E. -2 D. spher.

If, however, for further example, the correction here for distance in the right eye had been – 3 D. spher., and still the same cylinder combined with it,

$$\frac{-\ 3\ \text{D. spher.}}{-\ 1\ \text{D. cyl. axis } 180^\circ},$$

the glasses then prescribed for that eye for reading, would be the cylindrical lens alone, (— 1 D. cyl. axis 180°), and without any spherical lens at all.

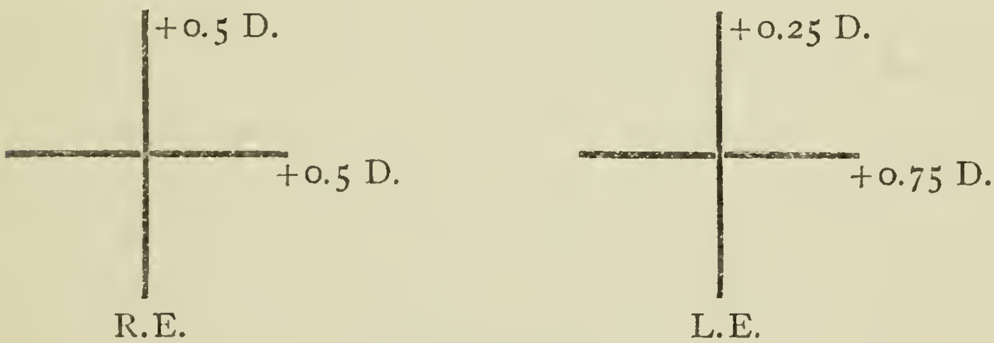
A presbyopic error is rarely found in the higher degrees of myopia—those of 7 dioptres and upwards. At times it may follow the ordinary course; whilst in other cases its occurrence may be somewhat retarded, or even be absent altogether. In each case this can only be ascertained by actual testing. When present, it follows the usual rule, and modifies the strength of the glass worn for reading; but it would in no way ever affect the strength of the distance-glasses.

When both eyes are myopic to the extent of 3 dioptres, or less than that, such glasses would only be used for distance, and none be required for reading.

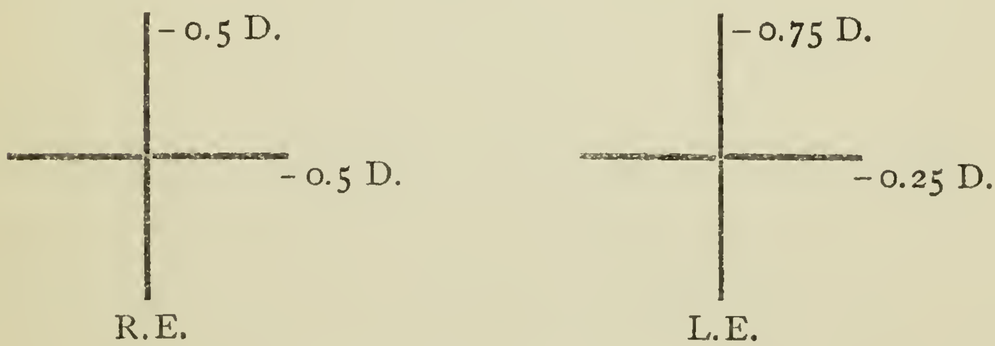
In prescribing glasses for the higher degrees of myopia, it should not be customary to give the full correction for distance, as that would induce a sense of overstrain. For very exceptional occasions the full strength might be allowed; but those that the patient is encouraged to wear constantly are intermediate glasses, which could also be made to serve for music-distance, and for wearing about the house. Such lenses might possibly be – 1 D., or – 1.5 D., weaker (*i.e.* less concave) than the full distance ones, and with proportionate allowance for the P.d.

measurement. But all reading and near-work would be done with lenses 3 or 4 dioptres less concave than those employed for full distance.

Quite low degrees of myopia are not unfrequently met with, which, though bordering on emmetropia, give rise to defective vision. By retinoscopy it may be found that, in both meridians of the eye, quite a low-power convex lens reverses the direction of the shadow movement; but after deduction has been made for the mirror, it proves to be a case of low-grade myopia. Any astigmatism present in such cases follows the usual rule. The following is an example:—



(*a*) Retinoscopy.



(*b*) After deduction for mirror.

The right eye in this case calls for no explanation. In the left eye the first formula (*a*) presents the axis of the cylindrical correction as vertical (90°); whilst in the second formula (*b*), after altera-

tion, the correcting lens, now a concave one, has the axis of its cylinder horizontal (180°).

At first glance this might appear contradictory; but in matter of fact it is exactly one and the same thing; in both instances it is the vertical axis that is the more convex one. This demonstrates that the position of axis of the astigmatic error as usually encountered in both hypermetropia and myopia, although expressed differently—vertical in hypermetropia, and horizontal in myopia—is not really dissimilar; but, on the contrary, it is an absolutely identical feature which is common to both.

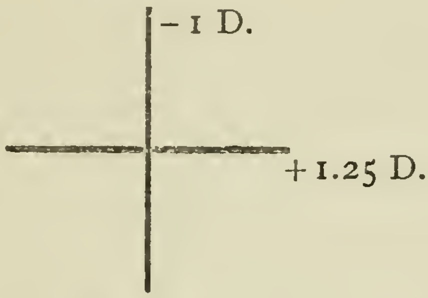
The seeming difference is simply due to the manner of regarding it. It is customary, for convenience of lens making, to consider the lower of the two figures in the formula as the spherical portion of the error of curvature in the lens; and the difference between that and the higher figure, as the amount of astigmatism. Therefore in hypermetropia the aspect is one which is directed upwards along the scale of lenses; whilst in myopia it is turned the other way, and is a descending one.

The condition of Mixed Astigmatism is another class of case not unfrequently met with, in which the true nature and degree of error are only revealed, with any certainty, by means of the retinoscopy test. In this, when allowance for the mirror has been made, the error is found to be hypermetropic in one meridian, and in the other at right angles to it, it is myopic.

(This differs essentially from Simple Astigmatism, where one meridian is either hypermetropic or myopic in character, and the other at right angles

to it is emmetropic. Compound Astigmatism is the class of case which has just lately been described and several examples given: both meridians in the eye presenting the same nature of error, but merely differing in degree.)

An example of mixed astigmatism, after deduction for the mirror, would be:—



When the patient is still in the dark-room the observer, in accordance with usual routine, verifies the finding and at the same time estimates the position of the axis of the cylinder. The myopic portion of the error is first neutralised with a spherical lens; but this also equally affects the hypermetropic portion of the error; and consequently, were the exact amount of the hypermetropic error then added to it in the form of a convex cylinder, it would not be sufficiently strong—owing to the presence of the correcting concave spherical lens that is already in the trial-frame. In order to produce the emmetropic appearance in response to the mirror, the convex cylinder must be increased accordingly by an equivalent amount, beyond apparent needs, to counteract this extra degree of error which has been thus artificially introduced. Here, therefore, in the right eye a concave spherical lens of − 1 D. would be placed in the trial-frame, and a cylindrical lens of + 2.25 D. with its axis vertical added to it (and not the lens + 1.25 D. cyl.).

The foregoing description applies, as a general rule, solely and exclusively to the examination in the dark-room. At the test-board and in daily use of the glasses, it is found that usually the patient attains best visual acuity and greatest permanent comfort, when the glasses are prescribed as if the eyes were simply ordinarily myopic, to the extent of the error shown in the meridian which is myopic. And in combination with this and added to it, would be a convex or plus cylinder, representing the simple hypermetropic error shown in the other meridian at right angles to it in the retinoscopy formula.

Thus, taking the foregoing example, it would be corrected as follows:—

Allowing for the mirror, and also possibly half a dioptre for the accommodation, a concave spherical lens, -2.5 D., would be used; and in combination with it a convex cylindrical lens, $+1.25$ D., with its axis 90° (vertical):—

$$\frac{-2.5 \text{ D. spher.}}{+1.25 \text{ D. cyl., axis } 90^\circ.}$$

But in this, as in every case, the strength of both such spherical and cylindrical lenses, and also the inclination of the cylindrical axis, must be verified by subjective testing. These spectacles would be worn for distance.

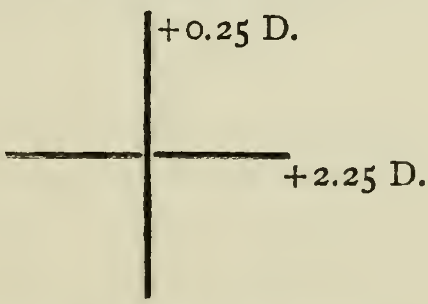
For reading-glasses, and for presbyopic correction, whenever necessary, the usual rules apply in mixed astigmatism exactly as in other cases, and on precisely the same principles.

There is no difficulty at all in these lenses being made; as the concave spherical portion is ground on one surface of the lens, and the cylindrical on the reverse side. And although the formula given in

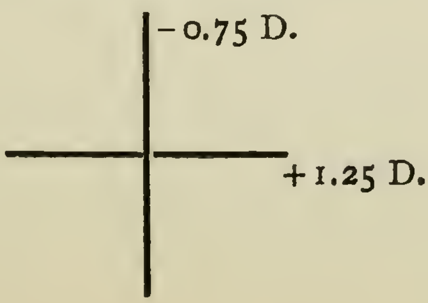
the prescription in these special cases of mixed astigmatism might be expressed differently, and often more concisely, it is always better to adhere to the form of calculation derived from the retinoscopy examination, as it retains clear evidence which may be of use in any future consideration of the case.

There are some cases of mixed astigmatism in which both the meridians are found by retinoscopy to be on the hypermetropic side of the zero-point —though the meridian of lower numerical value is brought to the myopic side of it after deduction for the mirror. The foregoing general rule is still followed: but in these particular cases it is often found that whilst the concave spherical lens is the usual one, the amount of the hypermetropic factor in correcting the astigmatism is represented by the difference which originally existed between the two figures before any deduction was made; instead of being just the difference that separates it from zero as already described.

Thus, retinoscopy might show:—



This, allowing for the mirror, is:—



And when possibly half a dioptre (0.5 D.) more has been deducted for accommodation, and the foregoing remark applied, the result would be:—

$$\frac{-\ 1.25 \text{ D. spher.}}{+\ 2 \text{ D. cyl. axis } 90^\circ.}$$

This would possibly give $\frac{6}{6}$ vision, and a perfect result with the radiating-lines test.

When the lens is no longer present in the eye (Aphakia), as after cataract extraction, the power of accommodation no longer exists. The reading-glasses then required, and quite irrespective of age, would simply be + 3 D. stronger, or more convex, than those used for distance vision; and if engaged at work which is at an intermediate distance, the suitable lenses would be correspondingly weaker.

CHAPTER IV

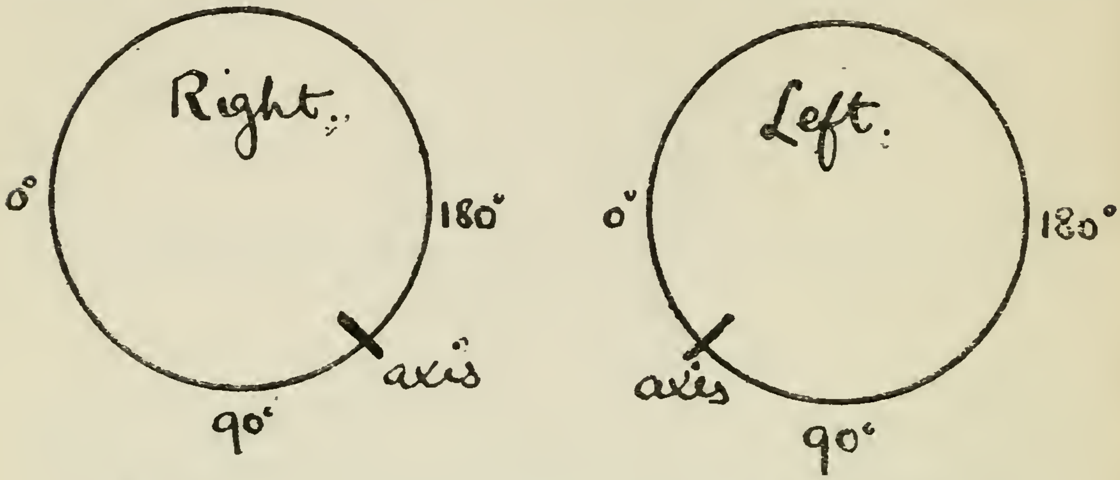
SYNOPSIS OF RULES IN PRESCRIBING SPECTACLES

In Emmetropia.—The correction of presbyopia alone requires attention. Cases at about the age of forty, or a little older, should take $+0.5$ D. spher.; and this increases at the rate of an additional half dioptre for every four years, until the age of sixty is reached; after this no further change, as a rule, is needed.

In Hypermetropia.—When general symptoms, such as headaches or neuralgias, are attributable to the local conditions, the strength of lens ordered is regulated by the amount of manifest hypermetropia present. When this does not exceed $+2$ D., the glasses possibly may be used for near-work only; but if greater than this, the same strength of glass would apply to the distance ones as well. There would then be one pair for distance, and another pair for reading; which would differ from each other only in the measurement of the inter-pupillary distance, beyond a slight necessary modification in the shape of the frame.

For momentary use the one pair of glasses might serve occasionally for either purpose without harm; but for any prolonged employment, such an interchange would tend to bring about recurrence of the local trouble.

When the age arrives for the presbyopic correction, this is added to the amount of the manifest



[*N.B.*—In the case of cylindrical correction it is advisable to indicate the position of axis as above; this represents the patient's eyes wearing spectacles, and facing the observer. The relative position of axis (0°, 90°, 180°) should also be shown in order to avoid possible confusion.]

DISTANCE.

R.E.	*+1.5 D. spher.*		L.E. *+2.25 D. spher.*	
	+0.75 D. cyl.	*axis, 135°.*	*+0.5 D. cyl.*	*axis, 45°.*
P.d. Measurement,		*64 mm.*	*Pince-nez.*	

READING.

R.E.	*+3.25 D. spher.*		L.E. *+4 D. spher.*	
	+0.75 D. cyl.	*axis, 135°.*	*+0.5 D. cyl.*	*axis, 45°.*
P.d. Measurement,		*58 mm.*	*Spectacles, curl-sides.*	

(*Name*)

(*Signature*)

(*Date*)

FIG. 7.—Specimen of simple form for prescribing spectacles.

hypermetropia present. The latter, it should be remembered, increases likewise as time elapses, and this necessitates the cases being re-examined.

In **Myopia.**—When it is greater than 7 dioptres, a deduction varying from 1 to 3 dioptres—or even 4 dioptres in the highest grades—is made for the distance-glasses, as the full correction would be likely to cause a feeling of strain.[1] The glasses for reading in this case may then be approximately the same strength as the distance ones; but it must depend on the choice of the patient.

When the myopia is of medium degree or less than 7 dioptres, the weakest concave spherical lens that gives the best visual acuity is ordered for distance; and those for reading should be 3 dioptres weaker. Music-glasses, which are convenient also for wearing in the house, would be of an intermediate strength.

In myopia of 3 dioptres, or still lower degree, no glass at all is required, as a rule, for reading.

In quite the very lowest grades of myopia it is found that the ordinary correction for presbyopia is not uncommonly required; though its onset may be delayed.

Many myopes, with a high degree of error, very unwisely prefer to read without any glasses at all, and simply hold the printed page close up to the eyes. Although the desired effect is obtained by this means, there are serious disadvantages accompanying it, and it is therefore to be strongly condemned. The object is magnified when held so closely; but there is a certain sacrifice in the degree of illumination, due to proximity of the head to the paper. Another drawback, in such cases, is that the near-distance becomes so much reduced in focal length, that it is a physical impossibility for

[1] See Note in Appendix. 'Telescope lenses.'

both eyes to be directed together towards it at the same time; consequently, the visual impression in one eye becomes unconsciously ignored, and divergent squint may be induced. These difficulties give rise to strain, and secondarily to congestion of the eyeball; this, in its turn, tends to soften the tissues comprised in the tunics of the globe, with consequent stretching. The final result is the axial increase in the length of the globe, which increases the degree of myopia; and in this way a vicious cycle is established.

In myopia it occasionally happens that the patient complains of objects being rendered smaller in appearance when seen through the spectacles, and more particularly those placed near at hand. The reason for this complaint is that formerly, when glasses were not worn, objects in order to be seen were held closely to the eyes, and appeared magnified; whilst, when viewed through the glasses, the objects are given their correct size and proportions. It should be, as previously stated, a strictly observed practice to invariably define the degree of myopia as being equal to that of the weakest concave lens with which the best visual standard for distance is attained. Any other subsequent correction—as for reading or music—is to be based on this; and when in doubt, the estimation of error must be confirmed by means of retinoscopy. With the possession of this knowledge, the prescriber is in a position to reassure the patient that the glasses are correct and the most suitable, and that the phenomenon of which they complain is due to the facts just described.

Another point in the treatment of myopia is that

patients sometimes state, since they began wearing glasses, they have become unable to see as well with the naked eye as formerly. This occurs for two reasons: firstly, because the eyes in their former unaided state were accustomed to interpret the hazy impressions which they received of outward objects, and when the glasses were adopted this habit was no longer exercised and became lost. Secondly, the eyes in wearing the glasses, being able to see so much more clearly, it was almost like a new world; so that the comparison with the former condition of indifferent visual perception becomes extremely marked.

It may be opportune here to remark that the habit of reading when lying down, which so many myopes favour, cannot be too strongly forbidden. It appreciably accentuates the local congestion, as the head is in the horizontal posture; and it may alone prove to be an incentive to the occurrence of myopia in the young subject, when there is no other apparent cause.

The instructions that are given to the patients in using their eyes for reading or other near-work, should direct them to keep this at a proper distance; and whether in daytime or with artificial light, it must be illuminated from the left and slightly from behind. This applies equally to all forms of error of refraction in using the eyes for near-work. There are, of course, certain occupations which are exceptional in their requirements, and these must naturally receive special consideration.

In **Astigmatism.**—Whether it is Simple or Compound in character, the strength of cylindrical lens prescribed for its correction continues exactly the

same, in both distance- and reading-glasses. When astigmatism is present glasses, as a rule, should be used both for distance and for reading. There is occasionally some intolerance of its full correction at first: this tendency can be overcome in great measure by the means already described (*see* page 40). And in elderly people more especially, where the error has not been previously corrected, the eyes may even refuse altogether to accept or work comfortably with the cylindrical glasses.

The strength of lens given to neutralise the astigmatic error must at no time ever exceed, although it may be less than, the degree that the observer has found by means of retinoscopy. But the axis of the cylinder is always adapted to the position, selected by the patient, that yields the clearest vision.

In Mixed Astigmatism the amount of error can only be detected with certainty by an objective test like that of retinoscopy. The degree of the myopic portion of the error is corrected in accordance with the ordinary rules governing simple myopia. The hypermetropic portion of the error is likewise separately corrected, but by a convex cylindrical lens. This usually represents either the difference between the two retinoscopy figures if they are above zero; or the amount that separates the hypermetropic error from zero; and whilst it may be a smaller amount than this, in practice it rarely exceeds it. Any alteration necessary in order to adapt the glasses for other purposes than distance, is made in the usual manner by modification of only the spherical part of the lens; whilst the cylindrical component of the lens continues the same without alteration.

In Anisometropia.—If the differing refractive errors in the two eyes approximate somewhat closely together in degree, it is advisable to correct each eye separately, in the endeavour to bring both up to normal vision; and with the expectation that no insurmountable difficulty will occur in the two eyes working together. When they cannot co-ordinate together in this way and confusion is produced, correction must be made in the eye that affords the better vision; the other eye being provided with a plain glass lens, merely to balance the weight of that in the other half of the spectacle-frame. It may only require a little perseverance and encouragement for the patient to acquire the habit of ignoring the image falling on the retina of the less perfect eye.

As a matter of fact, each case of Anisometropia must be tried experimentally, as it is impossible to lay down any hard and fast line of guidance.

It should be noted that in the higher degrees of error of refraction it is not always possible for vision to attain $\frac{6}{6}$ acuity; but the lenses then selected are those which yield the best visual result. In every case of such nature, careful investigation should be made to exclude the possibility of other reasons for the defective vision. This includes thorough exploration of the fundus with the ophthalmoscope; and also examination of the several media entering into the formation of the globe. Beyond this, the possibility of some more general affection in the body must not be overlooked.

The strength of all Reading-glasses ordered must invariably be based on the correction of the error, if any, as shown by the distance-test.

When the occupation is such that the point of vision is situated at some middle distance, less than 6 metres or "infinity" distance, and yet further off than that for reading—examples of which might be desk-work, music, or other similar employment, or manual labour; these glasses would be intermediate in strength, or less convex (weaker) than those for reading, and yet stronger than those for distance.

CHAPTER V

INTER-PUPILLARY DISTANCE

Reading.		Music.		Distance.
Distance from the eye :—				
30 cm. (book).	40 cm. (desk).	50 cm. (piano).	90 cm. (violin).	6 metres or further (infinity).
Inter-pupillary distance :—			(*Test.*[1])	
47 mm.	48 mm.	49 mm.	50 mm.	51 mm.
48 ,,	49 ,,	50 ,,	51 ,,	53 ,,
49 ,,	50 ,,	51 ,,	52 ,,	54 ,,
50 ,,	51 ,,	52 ,,	53 ,,	55 ,,
51 ,,	52 ,,	53 ,,	54 ,,	56 ,,
52 ,,	53 ,,	54 ,,	55 ,,	57 ,,
52.5 ,,	53.5 ,,	55 ,,	56 ,,	58 ,,
53 ,,	54 ,,	56 ,,	57 ,,	59 ,,
54 ,,	55 ,,	57 ,,	58 ,,	60 ,,
55 ,,	56 ,,	58 ,,	59 ,,	61 ,,
56 ,,	57 ,,	59 ,,	60 ,,	62 ,,
57 ,,	58 ,,	59.5 ,,	61 ,,	63 ,,
58 ,,	59 ,,	60.5 ,,	62 ,,	64 ,,
59 ,,	60 ,,	61 ,,	63 ,,	65 ,,
60 ,,	61 ,,	62 ,,	64 ,,	66 ,,
61 ,,	62 ,,	63 ,,	65 ,,	67 ,,
62 ,,	63 ,,	64 ,,	66 ,,	68 ,,
63 ,,	64 ,,	65 ,,	67 ,,	69 ,,
64 ,,	65 ,,	66 ,,	68 ,,	70 ,,
65 ,,	66 ,,	67 ,,	69 ,,	71 ,,
66 ,,	67 ,,	68 ,,	70 ,,	72 ,,
67 ,,	68 ,,	69 ,,	71 ,,	73 ,,
68 ,,	69 ,,	70 ,,	72 ,,	74 ,,
68.5 ,,	69.5 ,,	71 ,,	73 ,,	75 ,,
69 ,,	70 ,,	72 ,,	74 ,,	76 ,,

[1] Violin distance (90 cm. or nearly 36 in.) is the same as that for the retinoscopy test, and is the base of measurement for the other distances; it also applies to manual trades and to spectacles for ordinary wear in the house.

The foregoing table shows the relative inter-pupillary distances calculated from the base measurement described on page 10.

The measurement of the inter-pupillary distance is governed by the position of the *optical* centres of the two lenses, and must be modified in accordance with the purpose for which the glasses are needed.

Whenever glasses have to be worn constantly, from morning until night, separate ones are given for distance and for reading, even although the strength of lens is the same. This has been lately mentioned.

CHAPTER VI

SPECTACLES AND EYEGLASSES

THE glasses may be either in the form of spectacles or eyeglasses (pince-nez). When in the form of spectacles they may have either curl- or straight-sides: the latter are found more convenient when the glasses have to be changed constantly on and off the face, as with reading-glasses. The curl-sides occasionally require attention when they become too tight, or too slack, over the ear through use. This is easily remedied by drawing the wire firmly between the pad of the thumb and something hard, as by pressing it against a pen or pencil. In order to make the curl portion tighter, the pencil is kept on the under side of the wire; and to ease it or make it slacker, it is kept on the upper side of the wire.

Eyeglasses are preferred by many, although they are more trouble to keep correctly in shape or adjustment. They should always be of a suitable pattern so as to rest on the nose by balance, and without exerting anything but the lightest pressure there. The guards or clips, which rest against or grip the sides of the nose-bridge, should be adapted to the anatomical shape of the part; their long axis should correspond, or be parallel to, the axial direction of the nose, and not placed at right angles across it, as in some undesirable examples. When

thus correctly made, the guards should be set at an oblique angle relatively to the surface of the lenses; this pattern is generally known as one with "off-set" guards (Fig. 8).

When the eyeglasses are in position, the upper end of each guard rests against the bony roof of the orbit, above the inner angle of the eyelids; and it is prevented slipping forwards and so dropping off, by engaging, as it were, behind the muscle (*Musc. lev. labii super. alaeque nasi*) which forms part of the surface of the bridge of the nose there.

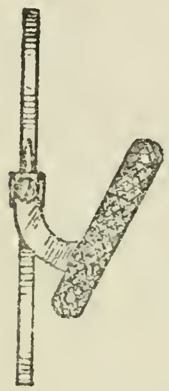


Fig. 8.—"Off-set guard" mounting (side view).

The guards are better left quite simple, faced with the bare metal surface; or, if desired, horn or other similar material may be used. Cork should never be employed for this, because owing to its being absorbent it is difficult to keep clean, and for this special purpose it must be considered unsanitary.

The position of the glasses on the face should bring the lenses as close as possible to the eyes, but without in the least touching the eyelashes. They should be horizontal, or absolutely level, as seen in their position across the face; and whenever they get out of shape, or their position is wrong, they ought to be at once re-adjusted.

It is wrong for any form of eyeglasses to ever injure or seriously mark the face where they come in contact with the skin. Anything of this nature is due to improper fitting, and must be rectified by the optician.

The question of the mount or frame may be left

to the individual taste of the wearer. Although lightly made, it should be sufficiently strong to be rigid, and so better retain its proper shape.

Rimless glasses have much to recommend them; as not only does this reduce the weight, but it often gives a better appearance.

It is quite a mistake to have the lenses too small. The ideal size is when the outside edge coincides with the line of the eyebrow above, and with the lower margin of the bony orbit below: this renders them practically invisible.

Special glasses are occasionally required for definite purposes, and with consequent modification in the shape of the lens. A large, partly circular lens is employed for games and for shooting; this dips downwards towards the cheek as far as the skin surface will allow but without touching it. For billiards large lenses are also advisable; but they should be decentered upwards, as that is the part of the lenses used; and the lenses should be set at such an angle that they are practically vertical when the head is in a position bent forwards.

Wherever possible the lenses should be periscopic or toric in form, otherwise known as "meniscus" lenses; these have the surface curved instead of being flat. The advantage they offer is that the curvature of the glass approximately corresponds to the curve of rotation in movement of the eyeball. In a flat lens—and more especially if of high power—the eye, in order to avoid prismatic effect and to gain greatest visual acuity, must be kept fixed exactly opposite the optical centre of the lens, and therefore always looking directly forwards. When an object is to one or other side, and there

is a wish to see it clearly, the wearer's head must be wholly turned towards it, in order to preserve this relationship between the eye and the flat spectacle lens. But in wearing toric glasses, on the other hand, the eye is able to alter its position naturally and more freely—rotating it upwards, downwards, or to either side—and still obtaining a good and uniform visual impression, and without the necessity of turning the head as well.

The reason for advocating these toric lenses is that they amplify the field of vision, and greatly conduce to the comfort and convenience of the wearer; moreover, when an object is in front of the wearer, the conscious peripheral field of vision is not restricted or distorted, as when flat lenses are used.

When only reading-glasses are worn, as in presbyopic cases, each lens may be cut away horizontally above the middle line, for greater convenience of the patient. The lower half or segment of each glass is alone mounted in the frame, so that the eyes obtain an uninterrupted view over the top, without taking them off; and yet at the same time the glasses are still ready in position for reading. These are called 'pulpit-' or 'half-' lenses. For library or office work, or even in ordinary daily life, this pattern is most useful, as otherwise the strength of the reading-glasses would cause objects to appear indistinct and blurred.

In low degrees of myopia where glasses are only required for distance, and none at all for reading, the lenses may be similarly cut across; but it is the upper halves which would alone be used then for distance; and thus no glass would intervene before the eye when engaged in reading.

In high degrees of myopia the glasses worn[1] are necessarily heavy, on account of the thick edges of the concave lenses. The difficulty is overcome by grinding the thickened portion away; this proves an unqualified advantage, as it considerably diminishes the weight and does not interfere at all with the area of the field of vision.

When two pairs of glasses of different strengths are worn, one for distance and the other for reading, it is sometimes of assistance to combine them in 'bifocal' form. The reading part of this lens may be a distinctly separate piece, fitted into a space cut from the lower half of the distance lens to admit it; or it may be separately ground as an inset on the distance lens; or it may be a separate piece cemented on to it, or even fused to it. This last is the most perfect form, and is known as a Kryptok-lens: in this the two lenses form one piece of glass together, and the reading portion is invisible unless examined under certain aspects.

Another means of obtaining the effect of a combined glass, is to prescribe the difference in strength between the distance and the reading ones, and to use it as a separate adjunct to the distance ones. If, for example, this strength needed is 3 dioptres, a rigid pince-nez fitted with + 3 D. spher., would be made with a small hook or 'grab' at each end of the frame; this is slipped on at will to the distance spectacles that are being worn: it is known as a 'grab-front.' For ladies it may be more convenient in the form of a lorgnette.

Occasionally request is made to wear a monocle or single eyeglass. Under ordinary circumstances this

[1] See Note in Appendix. 'Telescope-Glasses.'

should be discouraged, because it throws undue strain on the eye used, and favours disuse of the other eye.

Both field- and opera-glasses can have their eyepieces readily adapted with the correction for any error of refraction. This is sometimes useful, as they can be used without wearing spectacles; but it precludes their being available for other people, unless the alteration is adapted in the form of eyepiece caps, fitted over the others, and which can be removed.

When coloured or tinted glasses are required, those of neutral shade—known technically as 'London smoke'—may be ordered, especially when there is inflammation; they are preferable on occasions instead of a cardboard or other shade. Care must be taken that these glasses are 'true,' because it is not unusual to meet with them possessing irregular surfaces or other similar fault, owing to the fact that the lenses are moulded when they are made and not ground. This fault occurs not only in the cheaper qualities. Such a defect as this is found at once by moving them about in front of the eye; if objects then seen through them appear motionless, the glasses may be accepted; otherwise they should be rejected, as they would be likely to irritate an eye which is already hypersensitive, and might even cause recovery to be retarded.

A glass of greenish-yellow tone is the most suitable colour for protecting the eyes from glare, whether in the tropics or more temperate climates, or on the snow. There are several varieties of make, known by various trade-names, and all of them can be obtained in different grades of colour-intensity. They can be made up with the correction for any

refractive error, or simply as plain glass. This special colour affords great comfort to the wearer, and has the further advantage of scarcely diminishing, if at all, the clearness of definition or the visual acuity.

It is recognised that modern conditions of lighting often exert a strain upon the eyes, and the illumination is of such a nature that the protecting medium for ameliorating this must have the power of obstructing the ultra-violet rays that are emitted. It is customary to prescribe some form of tinted glass for this purpose, but owing to the light-interference afforded by such glass, it is not advisable to prescribe it for reading purposes. A special form of clear glass can now be had for this purpose, which permits the maximum transmission of visual rays, and at the same time obstructs those rays which exert an unfavourable effect: this is known as 'Uvex' glass.

This type of glass also affords special protection from the rays beyond the ultra-violet ones in the spectrum, which exert a harmful influence, as in X-ray work. Whenever it is necessary to also at the same time take precautions to modify the intensity of light or glare, that object is effected by the addition to the Uvex glass of a coloured or neutral tinted one, because by itself it does not afford sufficient protection in this way.

In those exposed to heat rays, it is advisable to prescribe glasses made in material which will have the converse effect to the above—allowing visual rays to pass freely, and at the same time absorbing the infra-red and the end-red rays. The colour of this glass is midway between blue and green.

For general outdoor use a glass can be obtained

which absorbs both end-rays (infra-red and ultra-violet); allowing the visual rays—the central portion of the spectrum—to pass.

For those whose occupation exposes them to intense direct glare of electric light, a combination of green and light red glass affords the greatest protection.

For goldsmiths, or others engaged in gold work, a glass of a delicate amethyst tint is particularly useful and soothing.

The instructions given to patients when using their spectacles for reading or other near-occupation, should direct them to accustom themselves to hold it at the proper distance from the eyes, so that, whether in daytime or with artificial light, it is illuminated from the left and slightly behind. There are a few conditions which require certain particular arrangements for lighting,—as in a drawing-office, etc.,—but this does not affect the general correctness of the foregoing rule.

The patient, in wearing either spectacles or eye-glasses, should be instructed to allow the optician opportunity for inspecting them at regular intervals—at least every six months, if not oftener, in order to rectify any error in adjustment that may have originated in wearing them. Unless thus kept in proper shape and order they not unfrequently become a source of annoyance and discomfort, which the patient may not be able to locate. Any optical firm of repute is usually prepared to render this service freely and without charge, as it keeps their work in satisfactory condition.

When the glasses have been made up by the optician, it is always advisable to have them submitted

for verification, before they are sent out to the patient. This obviates any possibility of error in making them up from the prescription ; also, if any complaint is made afterwards, this affords stronger grounds for the prescriber reassuring the patient.

It is not at all unusual for slight difficulty to be encountered at first in wearing glasses, even though quite correct; and this may extend over a week or two, before the patient becomes accustomed to wearing them unconsciously.

CHAPTER VII

THE ORDERING OF SPECTACLE-FRAMES

WHEN circumstances preclude the possibility of a personal visit of the patient to the optician, for the measurement and fitting of any glasses ordered, it becomes necessary for the practitioner prescribing them to then add sufficient further directions for the fitting of the frames. The essential details are as follows:—

A pattern spectacle-frame is used as a basis of measurement. It can be obtained from any reliable optician. This should be fitted with plain glass, and the pupillary distance of measurement of the frames should be 64 mm. The width, or breadth, of the base of bridge should be 21 mm. The temples or sides should be 150 mm. (6 inches) long, measuring from the pin of the joint to the end of the temple; which, if it is in the form of a curled side, should be stretched out in a straight line. The height of the nose-bridge (as measured from the middle of a line across the base of its arch, up to the highest point of its crest) should be 6 mm.; and its projection 2 mm. further forwards than the level of the front of the lenses.

This frame is used only as basis of measurement, and when fitted on the patient's face any errors or differences can be noted. The true measurements

are found by adding or subtracting such errors from the known measurement of the frame as now mentioned.

In practice the method of using this would be as follows :—

For distance-glasses the gaze of the patient must be directed forwards; whilst for reading, the eyes should be directed downwards at a book. The observer, in the case of distance-glasses, should be in front; but if they are for reading, should stand at the side and slightly behind the frame of the glass on the patient's face, noting whether the patient's eyes look directly through the centres of the lenses. If the frame is too low the observer raises it, and the gap then made between the bridge of the frame and the skin surface is measured. For example, if the measurement of this gap is 3 mm., it would be deducted from the 6 mm. of the standard, and so make the correct measurement for ordering 3 mm. If the lenses should be lower, more particularly for reading-glasses, the difference in position must be noted between the centre of the glasses in the pattern and the point in them through which the patient is looking. This should be added to the 6 mm. of the bridge-height of the pattern, in order that the glasses may become so much lower.

If the eyelashes touch the lenses, the frame is drawn sufficiently away from the face to avoid this, and the gap thus created between the bridge and the skin is measured antero-posteriorly: if this amount were 2 mm., it would make the ordering of the bridge 'flush.'

Another point to be noted is the bottom or base of the bridge, whether too wide or too narrow; and

the necessary correction would so far modify the measurement of it as represented by the pattern.

If the temples are too long or too short, the order is varied accordingly from the 150 mm. of the pattern. (When straight sides are ordered there is usually no need for this measurement.)

In exceptional cases it is necessary to state the width across between the temples: this is measured from a point on each side of the temple 25 mm. behind the centre of each joint on the frame.

It is advisable, as a rule, in the case of distance-glasses, to have the joints of the frames angled 5°; and for reading-glasses 15°.

The following table is a concise summary of the foregoing measurements:—

BRIDGE.	(*a*) Height....mm.	(*b*) Out....mm.	(*c*) Base....mm.
		Flush.	
		In.....mm.	
TEMPLES.	Length..........mm.		
	Width between......mm.		

CHAPTER VIII

AVERAGE PRICES OF GLASSES

As the medical practitioner may be asked at times by patients as to the probable cost of their glasses, the following list will give some indication. This represents the general average prices charged by the leading optical firms in London, and is based on the replies received in response to a circulated inquiry.

There are practically three grades of price, depending on the quality of material and workmanship; but much depends on the nature of the mount or frame selected by the patient. The second quality differs from the first in the cheaper class of material used, and in the handling of it by less experienced workmen. This latter factor directly affects the result, as the same degree of accuracy in the work executed cannot be expected; and as exactness is a feature of the highest importance in every detail of treatment in eye cases, it is deserving of serious attention. And, moreover, consideration should be given to the fact that this outlay is not a constantly recurring one.

The 'hospital quality' of glasses is provided in response to appeals made by the large charitable institutions, in order to aid necessitous patients coming under their care.

Spectacles and eyeglasses are procurable at certain shops and stores, at what might seem to be less cost than is set out here; but it is not accurate work, nor made up on prescription to the individual requirements of the patient. Also, it is always an unwise proceeding to select glasses at hazard, because harm is not unfrequently induced thereby. In many of the so-called 'sight-testing' shops, it is usually stated that no charge at all is made for testing; but the price then charged for the glasses is almost without exception inordinately out of all proportion to their actual value.

	Spherical.	Cylindrical.	Sphero-cylindrical.	Toric.
Spectacles with steel frames—				
Best quality . .	14s.	17s.	18s.	25s.
Second quality .	10s. 6d.	13s. 6d.	14s. 6d.	21s. 6d.
Hospital quality .	1s. 9d. to 2s. 6d.	3s. 6d. to 5s. 6d.	5s. 6d. to 7s. 6d.	...
Gold-filled . . .	14s.	17s.	18s.	25s.
Eyeglasses—				
Steel frames . .	10s. 6d.	13s. 6d.	14s. 6d.	21s. 6d.
Gold-filled . . .	14s.	17s.	18s.	25s.
Rimless spectacles—				
Steel	15s.	18s. 6d.	19s. 6d.	28s.
Gold-filled . . .	17s.	20s. 6d.	21s. 6d.	30s. 6d.
Gold	29s. 6d.	33s.	34s.	42s. 6d.
Rimless eyeglasses—				
Steel	15s.	18s. 6d.	19s. 6d.	28s.
Gold-filled . . .	17s.	20s. 6d.	21s. 6d.	30s.
Gold	25s. 6d.	28s. 6d.	30s.	38s. 6d.
Cemented . . .	5s. on above prices.			
Bifocal lenses—				
Kryptok and other special forms of bifocals . . .	about 20s. extra on above prices.			
Lenses per pair, for—				
Framed glasses .	4s.	7s.	8s.	15s.
Rimless glasses .	7s.	10s. 6d.	11s. 6d.	20s.
Prisms extra . .	5s. on above prices.			

CHAPTER IX

VERIFICATION OF GLASSES

WHEN the glasses have been received from the optician for verification, systematic examination of them must be made. The glass for each eye is examined separately. It is looked at from behind, as in the position they are worn; and in doing so care must be taken to keep the surface of the lenses parallel to the plane of the observer's face.

The first point to ascertain is the position of the optical centre in each lens (Fig. 9). This can be done without any special apparatus: all that is necessary is a fine black thread suspended on the middle of the window-sash or frame, and lightly weighted at its lower end to keep it stretched. If this is not convenient, a fine narrow line or marking, made on the wall or a card, will answer the purpose.

This testing is rendered easier, and is also more accurate, if the observer puts on a pair of spectacle-frames in which each of the lenses has been replaced by a piece of thin metal, and one of them pierced with a small central aperture.

The lens to be examined is held midway in position between the observer's eye and the vertical thread or line, and the arms are meanwhile steadied by resting them on some firm support.

It has been previously mentioned that when a lens

is moved from side to side, objects seen through it also appear to move—either in the same, or opposite direction, according to the description of lens.

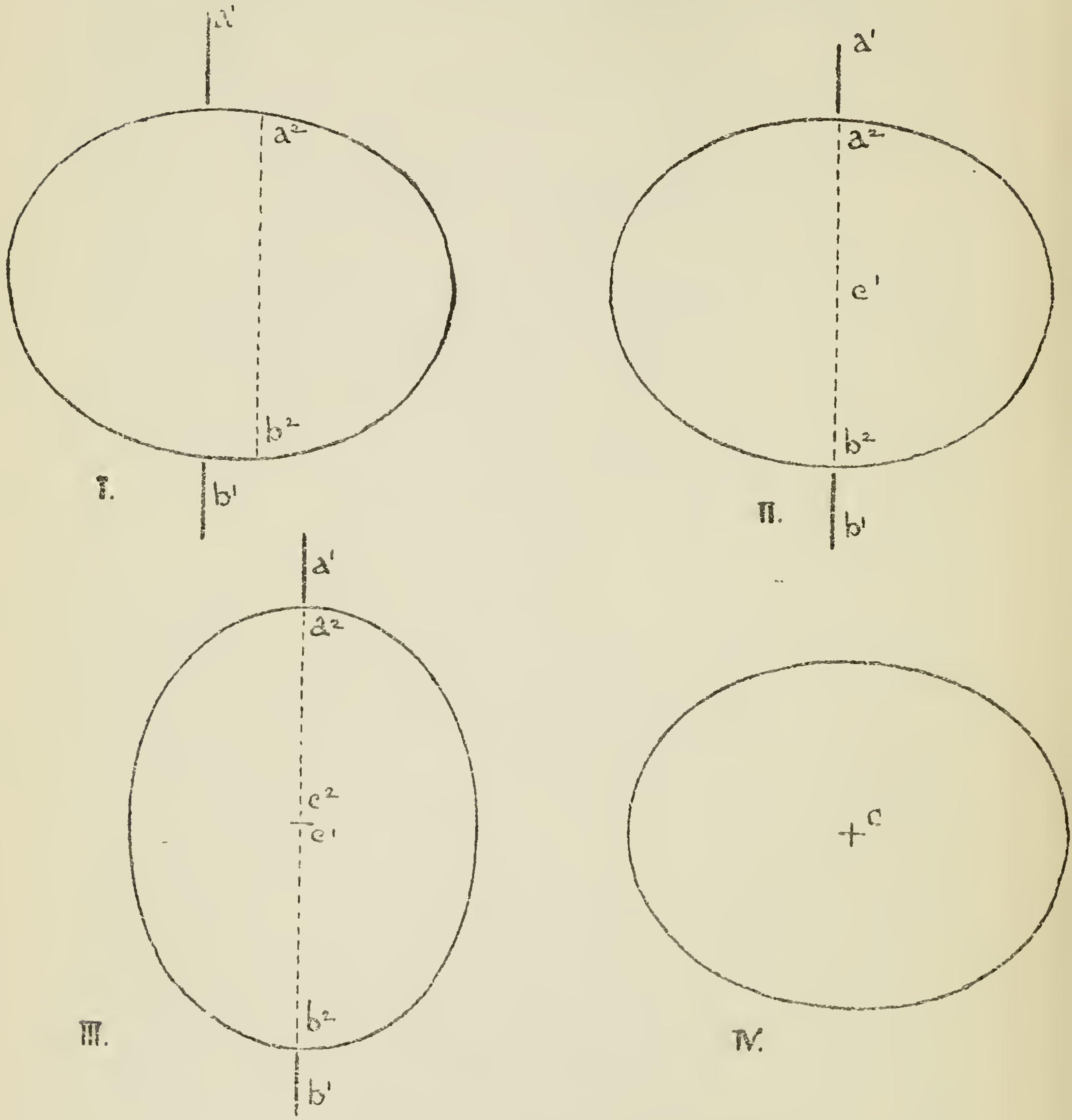


FIG. 9.—Verification of the optical centre in a spherical lens.

For this reason the portion of vertical line seen through the glass lens appears broken or interrupted at the upper and lower points where it is seen to enter and leave it (Fig. 9, I., a^1a^2, b^1b^2). This is

more clearly evident if the actual experiment is made.

Now, by moving the lens slightly to one or other side, this continuity of the line can be restored, so that its whole length appears perfect and unbroken (Fig. 9, II.). It should be noted that the upper and lower ends of this part of the line seen through the glass, must be made to coincide at one and the same time with the rest of the line showing both above and below it. A narrow mark is then drawn on the surface of the glass with a coloured grease-pencil or with ink, precisely over the middle point of the line that is seen through it. Afterwards the lens is rotated through half a circle, so as to be at right angles to its first position, and the same procedure is repeated (Fig. 9, III.).

The point on the lens at which these two marks intersect each other indicates its optical centre (Fig. 9, IV.).

Unless the axis is horizontal or vertical, the thread, as seen through the lens, appears diagonally (Fig. 10, I., a^2, b^2); the glass must then be twisted round until the line coincides correctly at top and bottom, and the glass is marked at each end and also at the centre (Fig. 10, II.). The lens is afterwards rotated to be at right angles to the last position, and is again similarly marked (Fig. 10, III.). The optical centre and the axis of the cylinder are thus indicated at the same time (Fig. 10, IV.): in this instance it is placed at 70°.

When the optical centre of each lens has been marked in this way, the millimetre rule is laid across from one to the other, and the correctness of the interpupillary distance that has been prescribed is verified.

Beyond making this measurement, it should be noticed that the two optical centres are relatively symmetrical in position; also, that they are equi-

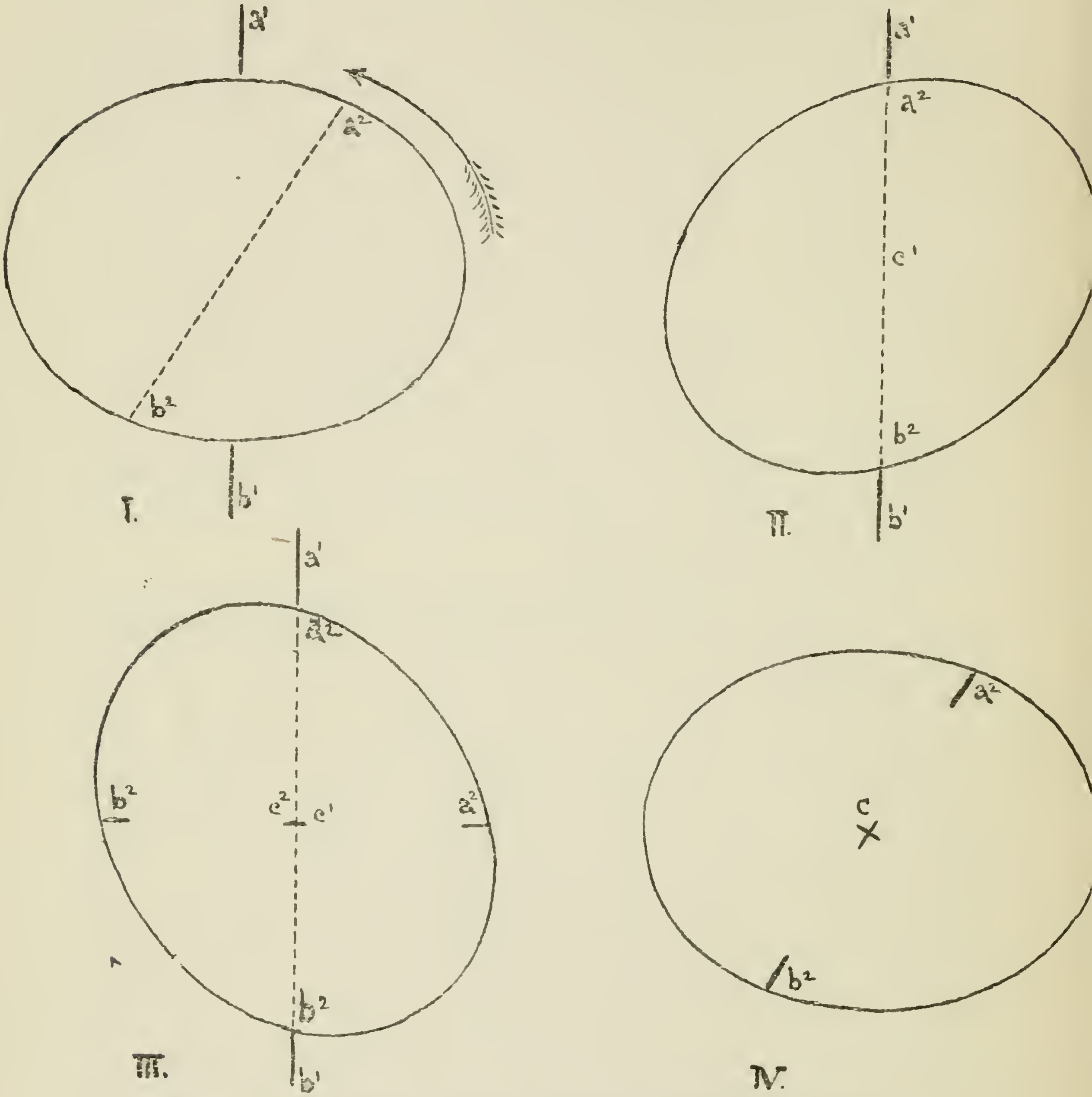


FIG. 10.—Verification of the optical centre and the axis in a cylindrical lens.

distant from the vertical middle line of the face or of the nose-bridge. It is possible that whilst the total inter-pupillary distance is in accordance with the prescription, there may nevertheless be serious

error, owing to one or both optical centres being displaced unduly to one or other side; or one of them may perhaps be found decentred up beyond the level of the other. Any of these conditions would be likely to give the patient trouble.

Occasionally difficult cases are met with, in which the eyes are set in the face either very widely apart, or very closely together. In these it is necessary to modify the position of the optical centres in both lenses — or 'decentre' them — outwards or inwards, as the case demands, in order to obtain proper and comfortable fitting of the frames on the face. In such cases the optical and geometrical centres of the lenses do not coincide with each other.

In other cases, the eyes are irregularly placed in their position in the face, and symmetry is lost. This requires special measurements. The best way to estimate horizontal displacement is to mark a short vertical line on the centre of the bridge of the patient's nose, whose gaze must be kept steadily directed towards a central point on the observer's forehead, and whose position must be exactly opposite and central. Measurement is then made with the millimetre rule from the central mark to the inner edge of the cornea of each eye in turn, and the two results compared. The observer examines with the eyes—left and right, respectively opposite the right and left eyes of the patient. Similarly, for any vertical displacement, a flat ruler may be held resting horizontally across the patient's face, whose gaze is fixed as before; then any difference can be measured in millimetres from this ruler up to the lower edge of each cornea.

After the correctness of the optical centres has been ascertained, the inclination of any cylindrical axis in one or both lenses is examined (Fig. 10).

The glasses are laid face downwards on the axis-diagram which is usually printed on the prescription form. Whilst the optical centre is placed over the central point of the diagram for the eye printed there, its long transverse diameter is kept exactly covering the horizontal axis-line on the paper that is marked 180°. The position of the axis that the pencil has marked on the lens can thus be verified. When the prescription is written on semi-transparent paper, it is placed with the printed surface against the window-pane, and the lenses are held in position behind it: each lens in turn thus corresponds exactly with the diagram, and the comparison presents no difficulty. Only when the prescription is on thick and untransparent paper is this placed on the table and the glasses laid on its printed surface. Allowance must then be made for the reversal of position of right and left eye, both in the glasses and on the prescription paper respectively; and the position of the axis is easily calculated by the number of degrees it is removed from either the vertical or horizontal meridians.

The strength of the lenses must now be verified: this is done by neutralising them. Corresponding lenses of converse strength—either convex or concave as required—are superimposed; this has been fully described elsewhere (*see* page 6).

It should be noticed in the case of reading-glasses, whether the front of the frame, or that portion which carries the lenses, is bent at an angle to the line of the sides or temples attached to it.

The tops of the reading lenses ought to be tilted forwards and downwards slightly, so that their surfaces remain at right angles to the axis of the visual line when engaged in the act of reading, and approximately parallel to the reading matter.

CHAPTER X

POWER OF FIXATION, AND SQUINT OR STRABISMUS

It still remains to direct attention to the Power of Fixation. This is the term applied to the intimate association existing between the act of accommodation within the eyes, and the rotation inwards of each globe that at the same time accompanies it: the latter is described as the Movement of Convergence.

These two actions are intimately associated, and occur normally together and to an equal extent in both eyes; and they preserve the same constant relative proportions to each other.

In Emmetropia they are balanced in perfect harmony, so that when the two eyes converge to look at a nearer object, there is a corresponding increase at the same moment in the power of the lens, due to the act of accommodation.

The focal image is clearly defined as it falls then on the macula in either eye; and at the same time it is still retained in position there when an object is brought nearer to the eyes, as both eyeballs simultaneously rotate inwards in converging towards it.

In Hypermetropia (when not corrected by spectacles) the degree of accommodation required

to produce a clear retinal image is a proportionately greater effort than in the normal eye. Accordingly, the relative degree of convergence associated with it is correspondingly so much greater that it is excessive. The consequence is that were this carried fully into effect, the correct alignment of vision would be disturbed by the over-convergence, and diplopia would result. This would be due to the extra degree of convergence in each eye, causing the image of the object to fall on dissimilar portions of each retina, and thus conveying the impression of two images to the brain instead of only one.

The hypermetrope, in the effort to overcome this difficulty, learns at quite an early age to unconsciously ignore the image seen by one of the eyes —usually suppressing that seen by the less perfect one; and although the excessive degree of convergence is still present, it becomes concentrated in, or limited to, the disused eye, and there produces an appearance of over-convergence or squint. This is known as Strabismus convergens.

Not unfrequently the young subject develops a habit of being able to use either eye indifferently at will under these circumstances, whilst the other eye alone—for the moment disused—exhibits the over-convergence. This is most commonly seen where the amount of refractive error is approximately the same in both eyes. This is alternating squint, or Strabismus convergens alternans.

In the case of Myopia a condition contrary to the foregoing is produced. Here, as the myopic eye, by reason of its altered anatomical shape and optical effect, can see any object if it is simply brought nearer to the eye than usual, there is no

effort of accommodation, and consequently no incentive for convergence. Added to this is the fact that in many cases the object is held so close to the face that it becomes a physical impossibility for both eyes to converge towards it at the same time, or remain in correct focus. The consequence of this is that a myopic person is apt to acquire the habit of inspecting a near-object with one eye only; and the other eye, which is meanwhile disused, remains either parallel in position or diverges outwards. This appearance is Strabismus divergens.

All efforts to relieve the condition of squint must invariably be prefaced by correcting the existing error of refraction, after it has been estimated under a mydriatic. In the adaptation of spectacles for young hypermetropic subjects, the remarks already made (*see* page 40) are applicable here.

Other means are also employed to equalise the power of the two eyes; as by occluding the better eye and encouraging the patient to use the other or misdirected one: this can be done by pasting a piece of grey paper behind the spectacle-glass of the better eye. The muscles of the globe may also be strengthened by appropriate exercises. Beyond these measures, or in combination with them, it may be advisable to operate; but this will receive separate consideration at another time.

Every effort should be made, whilst the patient is at quite an early age, to establish the use of the two eyes in conjunction together, or encourage binocular vision; otherwise that habit falls into abeyance, and may so far deteriorate as to become entirely lost. Not only may this harmful result occur, but the longer that the condition of squint

exists, so much the more does the acuity of vision itself diminish in the misdirected eye; and the more unfavourable therefore does the prognosis of ultimate recovery become.

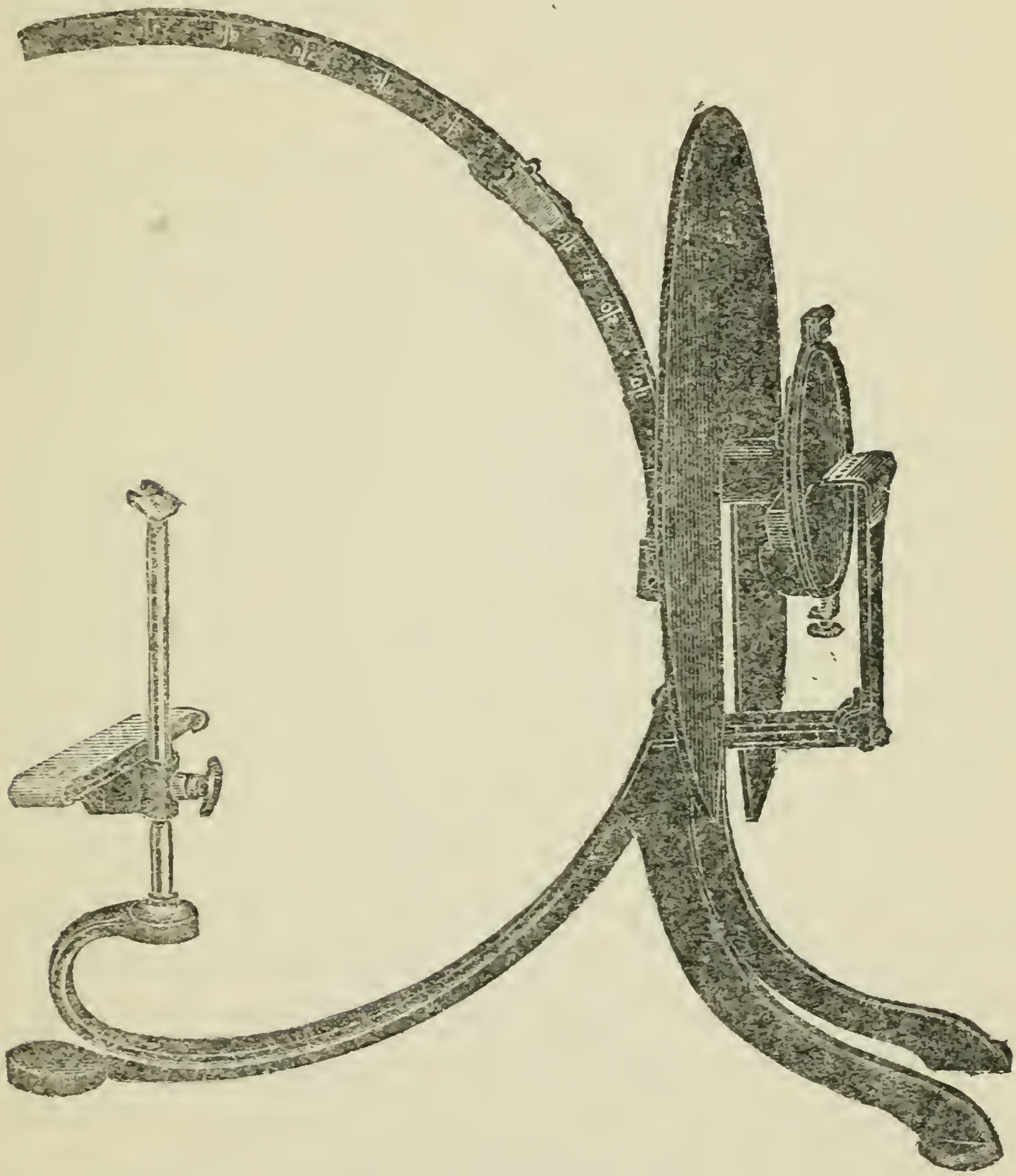


FIG. 11.—Perimeter.

It is unnecessary here to more than mention the fact that misdirection of the eye may be due to paralysis of one or more of the ocular muscles. When this is a purely local effect, the effort would be made to restore the lost function of the muscle, as by exercises, massage, and electric stimulation,

all of which would be locally applied; and, combined with these, the administration of suitable internal remedies.

In other cases the paralysis of eye muscles may be a local manifestation of pathological changes more remotely placed in the body.

In every case of misdirection of the eye, or squint, it is advisable to estimate the degree of displacement in the misdirected eye, for the object of comparison in the subsequent progress of the case. The most accurate method is by the use of the perimeter (Fig. 11).

The patient sits in front of the instrument with the face supported on the chin-rest, and with the misdirected eye occupying the middle position just above the small upright post: the gaze of the patient is directed steadily forwards to the spot marked on the centre of the arc, which should be turned horizontally. The observer then holds a lighted match or taper in front of the arc; and gradually moves it outwards, and whilst keeping close watch behind it, the reflection of the light on the eye can be presently seen shining on the exact centre of the cornea in the misdirected eye. The degree where this point is reached on the arc of the instrument indicates the angle of lateral displacement.

CHAPTER XI

OPHTHALMOSCOPE

IN the further examination of the eye the ophthalmoscope (Fig. 12) is employed for exploring the fundus, as well as the transparent media situated between it and the cornea. There are two methods available: the direct and the indirect.

The *Indirect* method is the one more frequently used, as it gives a wider and more general view, although less detail is evident. The image obtained is an inverted one; that is to say, everything seen is transposed in position, both vertically and horizontally; but in practice this does not prove to be any drawback.

The patient is seated in the dark room with the light placed behind the level of the face, either to one or other side, or above the head, whichever is preferred. The observer sits opposite at arm's length away, and holds the lens about $1\frac{1}{2}$ to 2 inches in front of the patient's eye, and keeps it steady by resting the fourth finger lightly on the patient's eyebrow or cheek. The concave mirror of the ophthalmoscope is the one used; it is held with the other hand close in front of the eye of the observer, who looks through its central round aperture. The light from the lamp which the mirror reflects illumines the fundus of the patient's eye; and by

gradual adjustment of the lens — backwards or forwards—a perfectly clear view of it is obtained. The observer, bearing in mind that the image is an inverted one, in order to extend the field of vision, must therefore move the head in a direction contrary to that which it is desired to explore. This effect can be still further increased by moving the lens in the same direction as the picture of the fundus, or in the opposite direction to the movement of the head and the mirror.

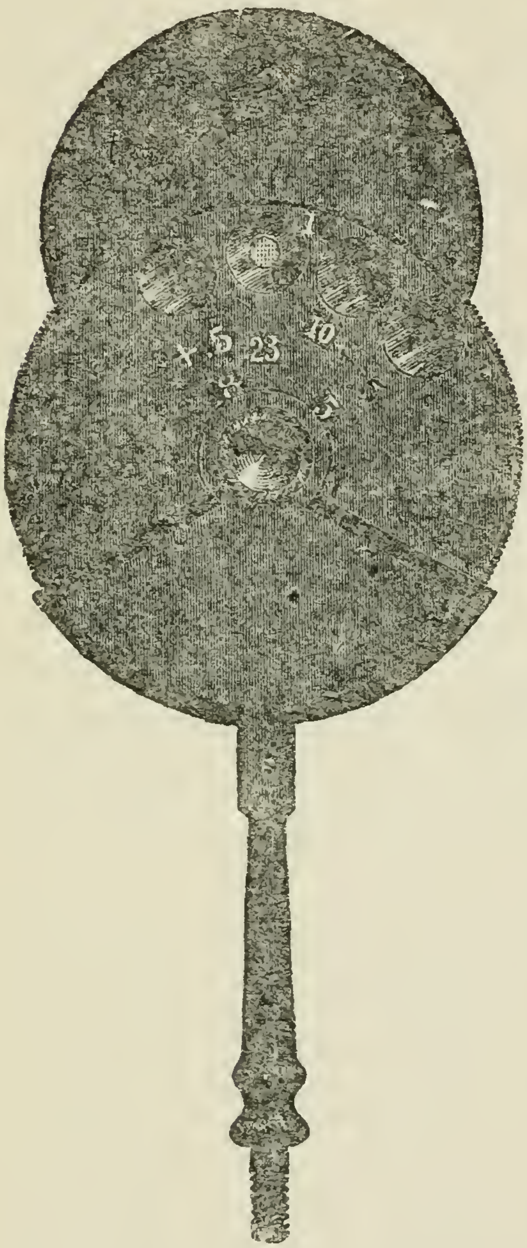


Fig. 12.—Loring's ophthalmoscope (back view).

The optic disc of the right eye is now readily seen by directing the patient to look at the extended fourth finger of the observer's right hand, which holds the ophthalmoscope. In order to see the disc of the left eye, the patient is told to look at the tip of the observer's left ear.

Then, by systematic movements — the patient being made to look upwards and downwards, and to either side, and lastly straight at the mirror—the whole area of the fundus may be fully searched.

Observation should be made as to the colour, shape, size, and contour of the optic disc, and of the vessels in relation to it; also the general area of the fundus, in regard to its vessels, structure, and pigmentation; the periphery is likewise explored and the fundus generally elsewhere; and last of all the macula. These are mentioned in this special order, as it is advisable to reserve the examination of the macula or yellow spot until the last; this is because its extreme sensitiveness incites the contraction of the pupil to light, and makes it more difficult, for the time, to afterwards obtain a good view of other parts of the fundus.

The *Direct* method in the use of the ophthalmoscope gives a more restricted view, but shows it in more magnified detail. The image seen is an upright one, and everything appears in natural position. The observer employs the ophthalmoscope alone, without the lens; the oblique smaller mirror is used, with its surface rotated so as to be presented to the source of light. The light is placed slightly to the rear of the patient's head, and to the same side as the eye which is under observation. If this happens to be the right eye, the instrument, with its handle pointing downwards, is held in the right hand close in front of the observer's right eye, who sits quite near to the right of the patient, and approaches the face until eyebrow almost touches eyebrow. In this position the light reflected from the lamp is cast from the mirror into the patient's eye and reveals every detail: if any difficulty at first is experienced, it is usually due to the observer not being close enough. Any error of refraction which may exist in the patient's eye, or

in that of the observer, can be suitably compensated by the small lenses contained in the body of the instrument. It is possible, by means of an electric attachment and small lamp adapted to the instrument, to dispense with the need of the ordinary lamp.

When examining the left eye exactly the same procedure is followed; but substituting 'left' for 'right' in every particular of the foregoing description.

By looking through the ophthalmoscope at a short distance away from the eye, and simply with the light reflected on to it from the larger concave mirror, it is possible, when the pupil is dilated, to notice any opacities which may be situated in the lens or other media: these appear as dark markings on the background, which is otherwise red in colour.

By this same means floating opacities may be discovered in the vitreous. These may not at once be evident; but whilst the light from the mirror is kept steadily on the eyeball, the patient is told, whilst not moving the head, to look upwards and downwards quickly, several times in succession; the eye is brought to rest finally by gazing steadily at the observer. Any opacities in the vitreous, if present, are thus set in motion and float into view. The feebler illumination afforded by the plane mirror, used in the same way, is sometimes advantageous for this.

Another method employed for examining the media of the eye is by Oblique Illumination. The lens belonging to the ophthalmoscope is held to one side of the eye, so that the light from the lamp is focussed on the cornea, the iris, or the lens. All

details thus seen may be enlarged, by the observer at the same time looking through another similar, or stronger, lens held in the other hand.

A largely magnified view of the cornea and anterior chamber of the eye may also be obtained by another method. The ophthalmoscope is used

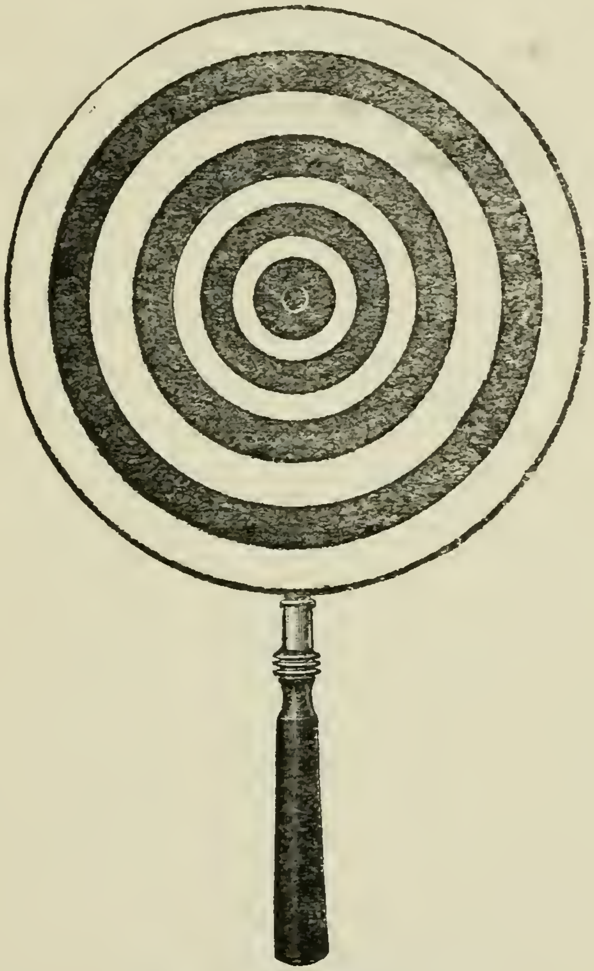


FIG. 13.—Placido's disc.

almost precisely as in the direct method, but the strongest convex lenses contained in the body of the instrument are introduced either singly, or in combination, behind the mirror.

There is a particular method of examination for detecting irregularites of the cornea, which, though perfectly transparent, may yet interfere greatly with the acuity of vision. This is by use of Placido's

Disc (Fig. 13). It consists of a piece of cardboard on which is a diagram composed of a concentric series of black rings drawn round a central aperture. The patient is placed with the back towards the window, and the observer, standing in front, holds up the disc and looks through it at the patient's eye. When this is normal the reflection of the rings seen on the cornea is perfectly regular and circular; but when any irregularity is present, the rings appear to be broken or distorted in shape.

CHAPTER XII

COLOUR BLINDNESS

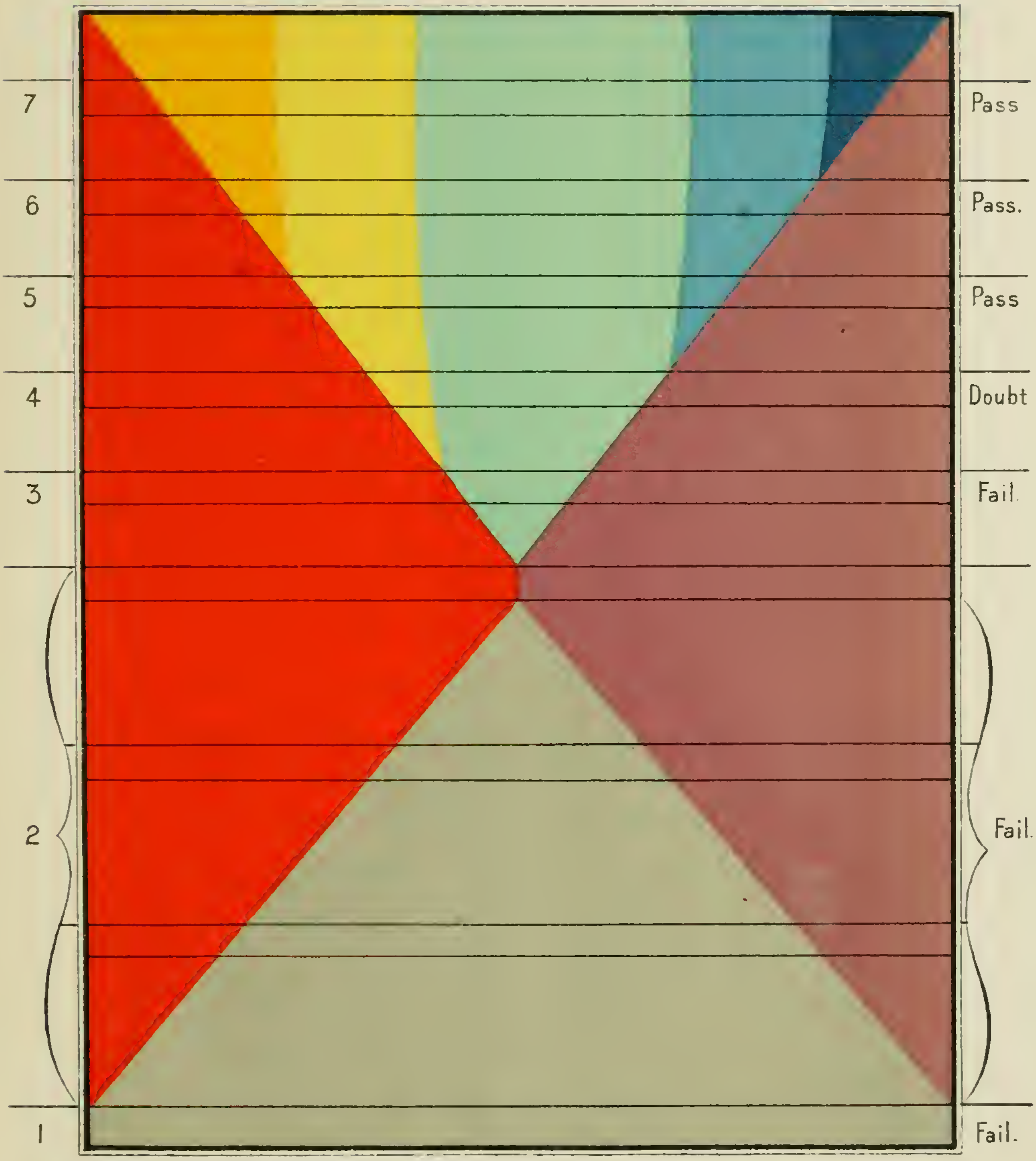
THE principles underlying the examination for Colour Perception admit of brief explanation. A beam of white light as it passes through a prism of clear glass is broken up into its component coloured parts, as seen in the spectrum band; and in this the distinct separate units of colour are always grouped in the same relative position to each other. When this spectrum band is projected on to a screen, and examined from left to right, it is seen that there are six principal colours—red, orange, yellow, green, blue, and violet, which occur in this consecutive order (*see* Fig. 14). These colour units form the spectrum band as seen by the average individual, and may therefore be regarded as the normal standard of usual colour-perception. A few people recognise a seventh shade, which is a deeper indigo blue, and separates the primary blue from the violet one: this, however, has no practical bearing here.

It is not uncommon to find that these units composing the normal standard of colour-perception are not distinguished by everybody; and therefore it is possible to generally classify people—following Dr. Edridge-Green's careful researches—in accordance with the number of colour units that they are able to recognise.

The orange-colour band is usually the first unit found to be absent in the least noticeable cases of deficient colour-perception. Next to that in degree of deficiency is the 4-unit, in which the blue band is unappreciated. The 3-unit degree, in which the yellow band is lost, is the class in which there is particularly the greatest risk of danger, by reason of the fact that the intermediate zone—orange-yellow—is absent; and these colour bands constitute the real element of protection or safeguard that, in natural conditions, lies between the red band of light and the green one. This defect becomes prominently important when, from any circumstances, either the retina is fatigued or special atmospheric conditions supervene: confusion then more readily occurs in distinguishing between the red and the green, and one colour is apt to be mistaken for the other. To this cause some most disastrous results have been ascribed, especially at sea and on the railways, where these two lights respectively denote 'danger' and 'safety.' When the full perception of orange and yellow colours is present, it forms a transition stage, enabling the individual to clearly recognise the difference between the two colours which occur on either side of it in the spectrum band.

It has been mentioned that those whose colour-perception is normal are grouped according to the number of colour units appreciated by them. The accompanying colour-chart (Fig. 14), that is in accordance with Dr. Edridge-Green's method of classification, shows the relative position of these deficiencies. In the 2-unit group the green band is absent. In this last class, by reference to the chart, it will be noticed that there are several grades of imperfection;

Degrees of Colour-perception.



(*After Dr. Edridge-Green.*)

Fig. 14.

because the two colours, red and violet, ultimately become more and more widely separated by a colourless grey tint, which finally replaces all colour sense or perception. And lastly, in the lowest group (No. 1), this grey shade alone replaces every colour, and the sole variation occurs in its apparent density.

It will be readily understood that in any test to determine the existence or extent of the colour sense in an individual, it is preferable to imitate, as closely as possible, the natural conditions under which it would be exercised. And as the ability to correctly discriminate between certain different colours is of most vital importance under ordinary circumstances, and at night time (especially on the railways and at sea, where the safety of so much—both in human lives and other values, depends upon it), it is essential when conducting any tests to closely reproduce the same conditions.

Various forms of apparatus have been devised from time to time, but it would be difficult to surpass, for compact simplicity and practical utility, Dr. Edridge-Green's Lamp, which is here figured (Fig. 15). This has been adopted by the Admiralty, several of the principal railways and shipping companies, and others. Beyond the various coloured glasses in it there are others; a neutral shade in four tones; a semi-opaque one to yield the semblance of fog; and another to give the appearance of rain. On the metal disc rotating in front of the light is a series of apertures graduated in size, so that the light may appear as if emanating from more remote and from defined distances.

The room must be darkened for the examination; and the patient seated 6 metres, or 20 feet, away,

and facing the lighted aperture of the instrument. The coloured glasses, or combinations of them (which again may be modified by interposing the secondary glass screens), are presented to the individual in turn, who must recognise them correctly and be able to promptly name them.

Diaphragm with graduated apertures.

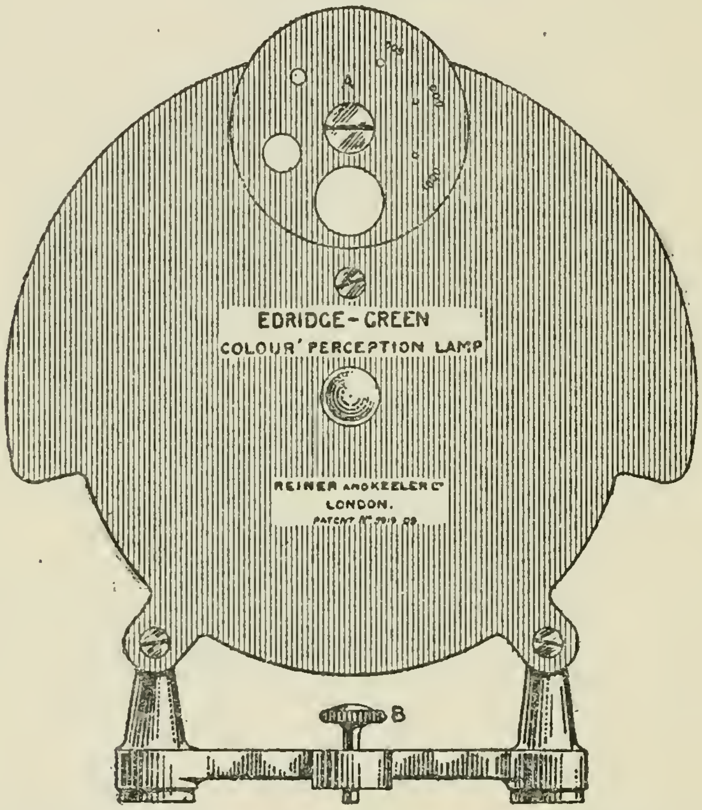


FIG. 15.—Edridge-Green's colour-perception lamp (front elevation).

Every detail of the successive steps in the examination must be carefully recorded: the size of the aperture used; the description and number of the screens interposed; and the answer of the individual, as well as the manner of giving it—whether promptly, decisively, or otherwise.

It is not advisable to follow any solitary prescribed routine in conducting any such examination; but it should be constantly varied, and seldom repeated.

In an individual of the 4-unit type, if it happens either that the body is physically tired, or perhaps the retina alone is fatigued, or the atmospheric conditions are unfavourable, it may be expected that the red light would be mistaken for a green one, or *vice versa.* Thus, though perhaps not colour deficient

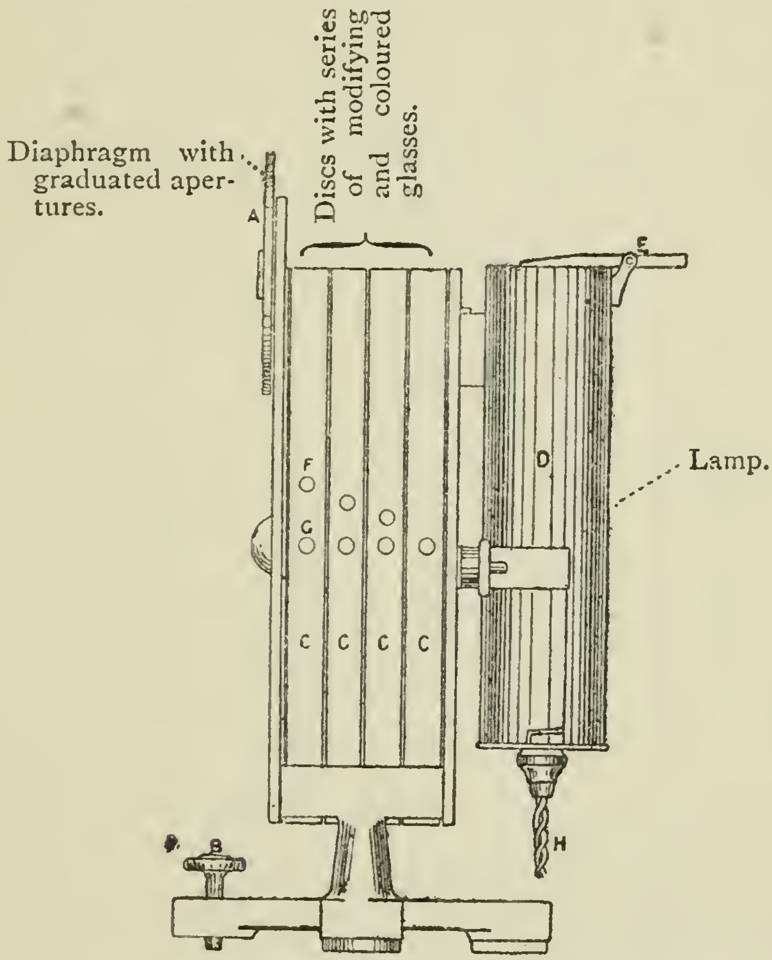


FIG. 15A.—Edridge-Green's colour-perception lamp (side elevation).

to any appreciable extent, the limitation or abeyance of the orange and the blue colour units proves sufficiently serious to constitute a real danger.

To examine the colour sense with assorted skeins of dyed wools, or with other test of similar kind, does not give reliable results; because the light is then a reflected one, and is further modified by the texture of the substances used; nor is the retinal

image produced, as regards size, comparable with the working conditions which the candidate would ordinarily experience. Whereas in the lantern test the natural conditions are closely reproduced, the colour is pure, and the light is transmitted.

Whilst there is the occurrence of functional colour blindness, there must also be recognised a perversion of the colour sense due to physiological changes. As examples of this:—Occasionally a lens in the process of becoming opaque and cataractous is at the same time tinted, so that objects appear of a yellow tone: this was instanced in the works of a noted artist, whose pictures painted in later life exhibited that peculiarity. Again, when there is effusion of blood in the interior of the eye, it is not unusual to find that the patient sees objects correspondingly coloured. Another instance occurs after the operation for the removal of cataract, when to the restored vision everything may appear to be of a bluish tinge: this has been explained as being due to blue being the contrasting colour to yellow, and so predominating on a retina that has been saturated previously with the yellow rays that filtered to it through the opaque lens.

Dr. Edridge-Green classifies the several degrees of colour-perception occurring in individuals in the following manner:—

7. *Heptachromic.* Those who see all of the seven colour units.

6. *Hexachromic.* Those who see all the units excepting indigo. (These form the average.)

5. *Pentachromic.* Those in whom the perception of orange, as well as the indigo, is also absent.

4. *Tetrachromic.* Those who further do not appreciate blue. (These individuals form a doubtful class as regards "safety.")
3. *Trichromic.* Where colour-perception is so reduced that only red, green, and violet are seen. (These individuals and others in the following lower classes must be rejected.)
2. *Dichromic.* These only see the two ends of the spectrum band—red and violet; and in this there are different degrees.
1. *Monochromic.* The colours here present no distinction excepting that of light and shade.

Then, further, either alone, or combined with these, the spectrum band may be simply shortened at one or other end—either the red or the violet.

It is unnecessary here to describe more precisely the details of Dr. Edridge-Green's Colour-Perception Lamp, and the manner of testing, as ample directions are issued with it.

The colour-plate (Fig. 14) represents diagrammatically the several varieties or grades of colour-perception; these are shown enclosed within the series of narrow parallel lines. (It would be more correct if the transitions between colours were blended, but here, for the sake of clearness, this has been omitted.) It will be noticed that the diminution is a gradual and systematic one, as regards the central portion of the spectrum, until the dichromic stage is reached; and then this, too, in turn gives way to the final monochromic condition.

CHAPTER XIII

SIMULATED BLINDNESS

When blindness is simulated it is not unusual to find that only one eye is affected; although this depends on the object which the patient has in view. In any case the procedure in the examination is the same.

It is most essential to preserve a sympathetic attitude towards the individual—as distinguished from a severe and antagonistic manner. If the blindness is genuine, this course is a correct one. If, on the contrary, the defect in vision is feigned, then detection is rendered easier; because any suspicion against the examiner becomes lulled, and the patient is more apt to perpetrate inconsistencies, thus leading to self-betrayal.

It is essential that careful notes are made of the various steps throughout the course of examination. Firstly:—

(*a*) The history of the onset is elicited—whether gradual or sudden; with or without pain, or other appreciable symptoms; also the patient's theory as to the cause.

(*b*) The vision must be fully examined in the ordinary way, and always beginning with the 'blind' or worse eye before testing the other. It should be ascertained whether there is any manifest

hypermetropia, or myopia, and whether astigmatism exists, and, if so, the extent of the error; or it may be possible to only note the distance at which fingers can be counted. Reading should also be tested.

There are cases occasionally seen where there is anisometropia (or marked difference between the refraction of the two eyes); or possibly one eye alone may be normal. Or there may be some pathological condition or other anomaly producing the same effect; and it is at times not until adult life, when some trivial occurrence directs attention to the abnormal condition, that it becomes known. The discovery is perhaps due merely to a fly or dust getting into the sound eye; or possibly from the individual being physically examined and being rejected on account of defective vision. In cases of hypermetropia also, advancing years diminish the visual acuity, even to a very marked extent, until it is corrected by glasses.

All these possibilities must accordingly be borne in mind, and final judgment reserved until a careful and detailed examination has been made.

The pupils should be carefully examined with resepct to their shape, their relative and comparative size, and to their reflex action—both as regards light and the power of accommodation. The light-reflex must be tested for each eye separately in the direct manner, whilst the other eye is meanwhile occluded.

The consensual reflex to light of the pupils must also be investigated. This consists in contraction of the pupil in the eye that is occluded, at the moment that the other one is suddenly exposed to a strong light. When the pupil of an eye that is

reputed blind remains immobile and dilated under strong light, but nevertheless a consensual reflex to light is observed in the other or sound eye, it affords strong supposition to the belief that vision is not really defective.

The absence of contraction to light in the pupil may occur from diverse causes. This reaction is lost under the effect of mydriatic drugs, whether instilled into the eye directly, or taken internally by the mouth; also in disease, as in tabes dorsalis, in progressive paresis, and in oculo-motor paralysis.

It is also noticed when there is paresis of the iris from increased tension of the globe due to inflammatory causes, or in glaucoma. It is found also when the back of the iris is adherent to the surface of the lens (*posterior synechiæ*). In these instances, however, the consensual reflex is present in the other or unaffected eye.

The only exception to the foregoing observations is found in uræmic amaurosis; here the reaction to light is present, even though vision is lost; this is due to the lesion being so high up in the optic tract. The symptoms are present in both eyes; besides which, other general physical indications would be present in the case.

The patient who is presumably the subject of simulated blindness, must be kept closely under observation during every test; and if it is found that the 'blind' eye is voluntarily closed at any time during the examination, it would adduce reason for suspecting the case to be one of malingering: the individual by such means endeavouring to ascertain the effect of the test, were the eye in question really blind.

The tension of the two globes is next compared, in order to exclude the possibility of any change: in glaucoma the tension would be increased, and if there were detachment of the retina, it would be diminished.

The fundus of each eye is now searched thoroughly by the ophthalmoscope, so as to examine and compare:—

(1) The optic discs, with regard to their colour, surface, and outline.

Here there may be pallor of the disc, as in an early stage of optic atrophy; or there may be swelling or tumefaction, if there is some local inflammation present; or hæmorrhages may be found in the retina around the disc associated with such a condition, and possibly indicating a more general ailment of the body. Also the condition of the retinal vessels is to be noted.

(2) The macula and the area around it.

Changes of an insidious or chronic nature may be located in the choroid, or in the retina, or in both; and are then either restricted in character, or form part of a change more widely distributed in the eye. Hæmorrhages—either idiopathic or traumatic—are not unfrequently found in this position.

(3) The periphery of the fundus.

Pathological disturbance, as in pigmentary retinitis, is frequently restricted at first to this region; and along with this there is pronounced diminution in visual acuity; nyctalopia (or inability to see at night-time) is also associated with it. Detachment of the retina, whether traumatic or idiopathic, or caused by a subjacent growth, is often met with in the distal portion of the fundus.

When examining the fundus with the ophthalmoscope, it is always advisable to do so by both the indirect and direct methods, so that no detail may escape notice.

In retro-bulbar neuritis, although there may be considerable alteration in vision, little structural change, or even none at all, may at first be noted. This would occur in toxic amaurosis, when there may be the symptom of hemeralopia (which is inability to see clearly during the daytime, although improvement may occur when the light is more subdued); this defect is usually restricted to the central portion of the field of vision, and colour-perception is likewise implicated. Later, the functional change becomes an absolute one, but even then the peripheral field may nevertheless remain unaffected. Ultimately, however, the change becomes a general one, and there is blindness, from optic atrophy having supervened, accompanied by narrowing of the retinal blood vessels.

The condition thus briefly outlined might be produced by tobacco—either smoking, chewing, or even the taking of snuff, and more especially when there is an addiction to alcohol as well. It should be remarked, however, that these habits need not necessarily be excessive, as some individuals are more susceptible than others to the toxic effects; and smoking is more liable to produce them if indulged in just after waking in the mornings and on an empty stomach. Disturbance of vision, and even blindness—but which is sometimes temporary,—may be produced by other substances, such as quinine, salicylic acid, stramonium, methyl-alcohol, lead, arsenic, chloral hydrate, iodoform, iodides, sulphides, male-fern, etc.; it also occurs in diabetes.

The symptom of hemeralopia may be observed, in incipient cataract, when the opacity is restricted to the centre of the lens. This is due to the fact that when the iris is contracted in strong light, it blocks out the vision which would otherwise be obtained from the rays passing through the more transparent part of the lens at the periphery. This applies equally to cases with central opacity of the cornea, although there it would be more obviously apparent.

Absence of the lens (aphakia), whether congenital, post-operative, or traumatic, is also a cause of lowered vision, although this depends, of course, on the pre-existing shape of the globe. In the normal eye, the absence of the lens produces a condition of hypermetropia, equivalent to an error of about 10 dioptres; but in an eye which is myopic in the same numerical degree (– 10 D.), the result would simply be to produce normal vision for distance.

The condition of aphakia is detected by examining the dilated pupil with a lighted candle, held closely in front of it and slightly to one side. In the normal eye where the lens is present, there are three reflections of the candle to be seen in a row, side by side; their appearance is known as the Purkinje-Sanson reflex-images. Two of them are brighter than the third one, which is central; and this last, though the largest of them, is quite faint and therefore is not used as an indication; it is erect in position, and is caused by the anterior surface of the lens. Of the other two images, one is erect and is the medium in size of the series; it is placed to one side, and is derived from the surface of the cornea; when the candle is moved this image follows in the same direction. The third and

smallest of the three images is an inverted one, and is placed to the other side of the large faintest reflection; it is caused by the posterior surface of the lens, and is easily seen to move in the converse direction to that of the candle. It is the presence of this smallest, brightest, and inverted third image, moving in the opposite direction to that of the candle, that always serves to indicate whether the lens is present in the eye or absent.

The iris, as might be expected when the lens is no longer behind to support it, frequently is seen to become tremulous when the eye is moved; but this is not always the case, and, moreover, the same symptom is not unknown when the eye is absolutely otherwise normal; it cannot therefore be taken as a guide. The appearance is described as irido-donesis.

After the eyes have been examined in all the foregoing particulars, and the various steps noted, resort is made to confirmatory tests, of which there are several specially devised to assist in the detection of simulated blindness. But it is advisable only to employ these as additional to the previous thorough examination, and not to place exclusive reliance on them.

The following selected tests are efficient, and are easy of practice under ordinary conditions; and with the exception of the first, do not entail any special apparatus:—

(*Test* 1.) There is the 'F R I E N D' test. The letters of this word appearing alternately in transparent green and red, against a black background. (This is generally made by fitting green and red slips of glass in turn, side by side, and mounted in a frame; and then covering them with a black paper or thin

metal mask in which those letters have been cut out.)

A spectacle trial-frame is then fitted on the patient, with a piece of plain red glass in it opposite the good eye, and plain green glass in front of the other one that is presumably blind. The patient, hitherto placed in a position so that the coloured test cannot be seen (which is best suspended in front of a window), is now turned round and told to read it. If the one eye is really blind, only the red letters, 'R E D' are seen; but if, on the other hand, the eye in question is not truly blind, more letters than these are seen—and even possibly the whole of the word is deciphered, if the patient is still unsuspecting. This result occurs because the red glass neutralises the green one and prevents the transmission of light through it; and consequently, the green letters become merged in the black of the background, whilst the red ones remain unchanged.

The test may be varied by changing the places of the red and green glasses in the spectacle-frame; and then the foregoing description applies similarly, excepting that the colours are transposed and the letters 'F I N,' in green, only are visible.

The precaution must be taken to have the tints of the red and green glasses such that they completely neutralise each other when held up to the light; otherwise the glimmer of the other coloured letters would still be seen, even though faintly, and the success of the test would be nullified.

It is best in all these and the following tests to adopt some degree of method, in order to obviate the possibility of subsequent confusion when tabulating the results. Thus, for example, it may be easier

to remember mnemonically the manner of testing, if it is customary for the observer to place the red glass always in front of the reading (or sound) eye.

(*Test* 2.) A sentence is first written out legibly in

EXAMPLES OF PARTI-COLOURED TESTS
(*Tests 2 and 3*)

Next, after an interval of about half an hour, came several men mounted on camels, and each one beating a pair of large copper kettle-drums attached to the forepart of the saddle.

One must never
talk loudly here
whilst others continue
to listen attentively.
Standing Order.

A loud and confused din resounded through the great portico, and there was not anything as yet to be seen or heard, and indeed little afterwards.

FIG. 16.

good-sized characters, with ordinary black ink on white paper; but with certain selected words, or portions of words in it, differentiated by being written in red ink. For this purpose another pen, but of the same make, must be used; so that there may be no

difference evident in the form of the writing, except in the colour alone (Fig. 16).

With the spectacle-frame placed on the face, and the red glass in front of the sound eye and the green glass in front of the other one, the patient is told to read out, quickly and aloud, the specially prepared writing. When both eyes are sound *all* the words are seen and appear uniformly black. If, on the contrary, the eye with the green glass in front of it is really blind, only the black lettering is visible: the whole of the background—formed by the white paper, and now seen with only one eye looking through the red glass—is uniformly red in colour; and the red writing on it is entirely effaced and therefore no longer distinguishable.

This will be more easily followed when the reader essays the actual test experimentally.

It is advisable to prepare the paper especially for each occasion, because then that portion of it in coloured ink is fresher and brighter, and there is less likelihood of the test becoming known: also, it should be kept folded on itself—or the writing otherwise completely concealed—until the moment of use.

Any evident effort on the part of the individual when examined to close the suspected eye, or any studied pause or hesitation when reading, would be strong presumption that the case was one of malingering.

(*Test* 3.) With the use of similar black and red writing, and with the red glass only in front of the sound eye and nothing before the other one, the patient is told to read aloud quickly. When both eyes are sound it is read continuously; but if the eye without

the covering glass is blind, only the black wording is visible.

(*Test* 4.) A pair of empty spectacle-frames being placed on the face, the individual is told to read aloud from ordinary fair print: a strong prism, with the base up or down, is presently interposed suddenly in front of the supposed blind eye. If both eyes see, some confusion is produced, causing momentary hesitation. None at all, however, occurs if it is the sound eye only that is able to read.

(*Test* 5.) Place a candle in front of the good eye, and move it slowly across the face, telling the individual to keep looking straight forward and to intimate when it can no longer be seen. By a malingerer it will still be seen when the light is concealed by the dorsum of the nose; or it will be stated to have disappeared before this is actually the case. Falsity can be definitely detected by noticing the position of the shadow which is formed by the nose on the skin of the face.

(*Test* 6.) Two candles are lighted and placed on a table or shelf close together in a room, at some little distance away. Then the view of them is intentionally obstructed for a moment by the body of the observer, when in the act of inserting a strong prism—either with the base out or in—before the good eye in the spectacle-frame. An assistant, at precisely the same moment, removes one of the candles. To a malingerer there are still two candles seen when questioned; but, if one eye is really blind, only the one candle is evident. (In this test the observer must assume tacitly that the two lights are still seen, and simply ask the question as to their position.)

(*Test 7.*) Make the patient close the good eye, and then give instructions to place the hand in front of the blind eye. A genuinely blind man does this correctly; but a malingerer will intentionally hold the hand elsewhere, trusting to thus emphasise the existence of his assumed defect being confirmed.

Similar tests might be multiplied further, but those instanced here will prove sufficient for most purposes.

CHAPTER XIV

THE MEDICAL INSPECTION OF THE EYES AND EYESIGHT OF SCHOOL CHILDREN

SOME of the obvious facts which claim the attention of the casual observer, do not necessitate the skilled opinion of the School Medical Officer. The following are examples of these:—Children may exhibit about their eyes signs of inflammation or active pathological change, such as styes, swelling or redness of the lids or at the roots of the eyelashes; or there may be increased vascularity, locally or generally, in the eyeball, and possibly accompanied by intolerance of light and excessive lacrimation. In these instances active steps should at once be taken to place the child under special medical care, to arrest further progress, and if possible to remedy the cause.

Many of these persistent recurring attacks of inflammation in the eyes or eyelids are from local strain, due to some error of refraction in the eye; and improvement results when this has been corrected.

All scholars must be drafted off for special medical attention when there are symptoms of the eye-muscles being affected, as by squinting, quivering movement of the eyeball or nystagmus; also those who complain of headaches, or of tiredness about the eyes,

or who habitually blink or screw up the eyes, or who hold the head sideways or bend too closely over their work. And in addition those children who appear unaccountably backward in their classes; because, in many instances, this is found simply due to some error of vision that interferes with their ability to work so well as their comrades.

In all those instances coming under the teacher's notice, arrangements should be made for fullest examination of the refraction under a cycloplegic, beyond the ordinary treatment required for the local inflammation.

The teacher must subsequently notice that the spectacles fit properly and are kept in proper repair. The centre of each eye should coincide with the centre of the lens in the spectacle-frames; the eyelashes must not, under any circumstances, rub against the glasses, nor the bridge press into or injure the surface of the skin. Any of these defects would interfere with the benefit accruing from the proper use of the glasses, and all can be remedied by any competent firm of opticians.

The vision of all pupils—whether newly enrolled or older ones—should be tested at the beginning of each scholastic year; and if below the normal standard, the eyes should be submitted to examination by an ophthalmic surgeon. This annual test ought to be easily carried out correctly by the teacher under the guidance of the School Medical Officer.

The ordinary Snellen test-types may be used for this purpose, placed at 6 metres (20 feet) away from the child, with the light falling on them from the side; every child standing in turn so that the light

does not fall directly on the face, should have each eye tested separately. When any eye is unable to read the letters designated on the board as D. = 9, the case must be relegated for fuller examination.

In the fraction used for expressing visual acuity, the numerator indicates the distance away from the test-board, and the denominator records the lowest line the eye can read there. Thus, Vision = $\frac{6}{6}$, means that the eye tested at 6 metres from the board, sees the line which the normal eye would read at that distance. If it is found that Vision = $\frac{6}{12}$, this proves that the eye at a distance of 6 metres can only read the line which the average individual would see at 12 metres away from the board; therefore the vision is $\frac{6}{12}$ of normal. Care must be taken when occluding each eye in turn, that no pressure is exerted on the globe of the eye which is closed; it is therefore better, for this purpose, to simply interpose a card in front of the eye, with its edge resting lightly against the bridge of the nose.

The vision of children under six years old should not be tested in this way, as they are not sufficiently conversant with the alphabet to make the examination a dependable one.

In the case of a child with spectacles, they should be worn whilst the teacher is testing the vision.

When any discharge accompanies the inflammation of the eyes, it becomes the duty of the teacher to at once inform the School Medical Officer, and in the meantime to keep the child from coming in contact with the other children of the class. Also to take precautions that in the lavatory there is no possibility of the same hand-basin or towels, or even the child's handkerchief, being used by the others. It

is only when a competent medical authority has certified that the condition of the eye is not infectious, that this embargo on the actions of the child may be removed. By this means infectious inflammation of the eyes can be checked, or prevented becoming epidemic.

It is unnecessary here to more than simply allude to the facts observed regarding the incidence of visual defects during the children's period of school-life. Published statistical records prove that there is a strong tendency towards the development of any pre-existing or congenital ocular defects; and that these become more accentuated during school years, under the constant and prolonged strain to which the eyes of children are subjected in modern methods of education.

Instead of the eyes being allowed quietude and freedom to properly develop during the earlier years of childhood, a stress which can be harmful is imposed on them by the scholastic routine to which they are subjected.

The eye whilst ordinarily at rest, and also in the natural position for use, is expressly adapted for distant vision; and it is only when focussed for nearer objects, as in reading or writing, that a sustained muscular effort is brought about in both the extrinsic and intrinsic muscles of the eye acting conjointly. Furthermore, because during the earlier years of life the natural movements of the body are principally confined to the groups of the larger muscles, the unwonted exercise of the eye automatically induces a fuller blood supply to it. This, in its turn, tends towards greater softening of the external coats, producing abnormal expansion of the globe

and deformity in its shape. Myopia, or other error of refraction, therefore more readily occurs, and the visual acuity becomes diminished; and the child's education becomes carried on under increasing difficulty.

The only means of obviating this calamity is to regulate the methods of education and environments of the children by proper hygienic precautions, so as to lessen or remove every possible cause of eye-strain. This is in addition to the necessary correction of any visual error by means of spectacles.

The latter ought to be carried out by some specially qualified physician or surgeon, who alone is competent to conduct an examination under a mydriatic; and the services of the so-called Sight-testing Optician, acting in his commercial capacity, must be rigorously excluded.

The close attention of the School Medical Officer should be given to the important questions concerning the proper construction of the schoolrooms, school-furniture, and the educational materials used by the children; also to the methods of education, both generally and in detail.

In the architectural plan of a school, beyond the arrangement of the building, the situation and the position require careful consideration. These must be suitable and healthful, whilst easy of access and conveniently situated to the homes of the children: absence of distracting noises, and the freedom from smoke, fumes, and dust are also advantages. There should be ample surrounding space for playground, which should not all be open, but part of it covered in for use in bad weather.

For preference the classrooms should be narrow

and oblong, lighted by windows along the left side, and slightly to the rear as well: the room should look out on an unobstructed area, so that as much sky as possible is seen from every seat.

The windows must be on one side of the class-room only, so as to avoid cross-lights. The jambs of the windows must be bevelled, and the windows be grouped together so as to avoid unnecessary shadows.

The pupils should sit in rows across the short width of the room, with their faces all towards the end where the black-board is placed. Neither the position of the pupils nor the teacher should directly face the light.

The window surface must be equivalent to at least one-fifth of the total floor space, and the height of the window equal to two-thirds of the width of the room. When the classrooms are on the ground level, extra allowance of relative window surface must be provided.

Roof-lights are not advocated; they are hot in summer and cold in winter, and the shadows they produce fall wrongly for school-work.

If by force of unavoidable circumstances there are windows on opposite sides of the room, those on the right should be high up so as to illuminate the ceiling. It is better to obtain extra illumination by the use of hinged reflectors; these are placed at a sloping angle of about 35° outside the windows; they project light up to the ceiling; from this, in turn, it is thrown downwards into the room.

If there are close adjacent buildings that cannot be avoided, their surfaces should be whitened.

In northern latitudes a south exposure is the

most favourable, being brighter, more cheery, and also warmer; and it yields the greatest average illumination throughout the year. The only exception is in the case of a drawing-class: the room for this is better with a north aspect, because the constant variation in light caused by passing clouds, and the alteration in the position and intensity of direct sunlight, are disturbing for drawing.

The best average illumination is found in a room at 12.30 o'clock. Therefore, if that be regarded as the standard daylight illumination for any particular room, the lighting, if only just enough at that hour, will be 33 per cent. less at 4 o'clock in the afternoon. Accordingly, it is almost impossible in this country to overlight a schoolroom, provided that sunlight does not shine directly on the eyes of the pupils, nor is reflected on to them from any glossy surface.

There is a choice of methods for the determination of the intensity of illumination in a room, whether lighted by daylight or artificially. Several photometers[1] are made for this purpose; there are also printed test-types to be viewed through glass screens, the latter being arranged in graduated series of successively deeper tints.

When artificial lighting has to be used, electricity forms the best medium, because of its greater adaptability and coolness, and the absence of fumes. The light bulbs should be under perfect and easy control, and ought to be distributed throughout the rooms at intervals, rather than placed in a few clustered groups. It is not always possible in a large schoolroom to strictly adhere to the principle

[1] See Appendix. 'Photometer.'

that the light shall always emanate from the left of the pupils; but care should be taken that the arrangement of the lights allows of the strongest shadows falling correctly in accordance with that rule.

The lights should never be placed high up close to the ceiling, but be suspended lower down. The

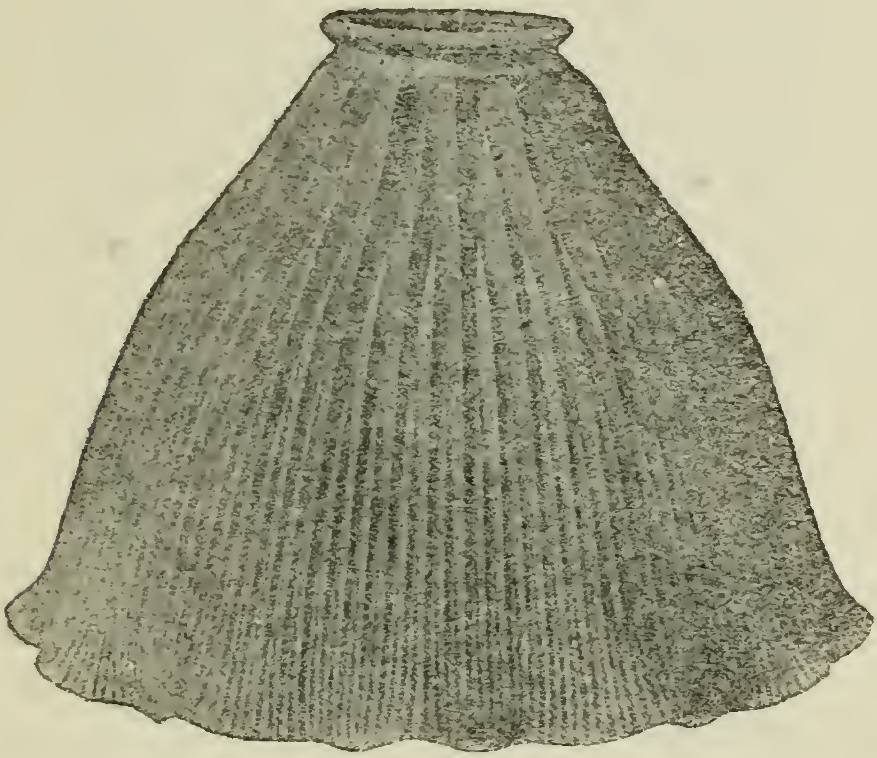


FIG. 17.—Holophane reflector (intensive type).

most perfect form of lamp is one equipped with a bowl-type Holophane reflector (Fig. 17): this is of glass, and made on strictly scientific principles with regard to the distribution of light. A metallic filament lamp of spherical shape, and with its lower part frosted, is placed pendent in it; and unless the reflector is looked up into directly from below, there is no view of the intense light from the bare filament, which is painful and injurious. The glass reflector collects all the light, and re-directs it downwards as

far out as an angle of 45° on the horizontal plane below. In order to derive uniform illumination, these fitted reflectors should be distributed in the room at a distance apart equal to twice their height above the plane which they illuminate.

The switches controlling the lights should not all be clustered together. A few only are placed near

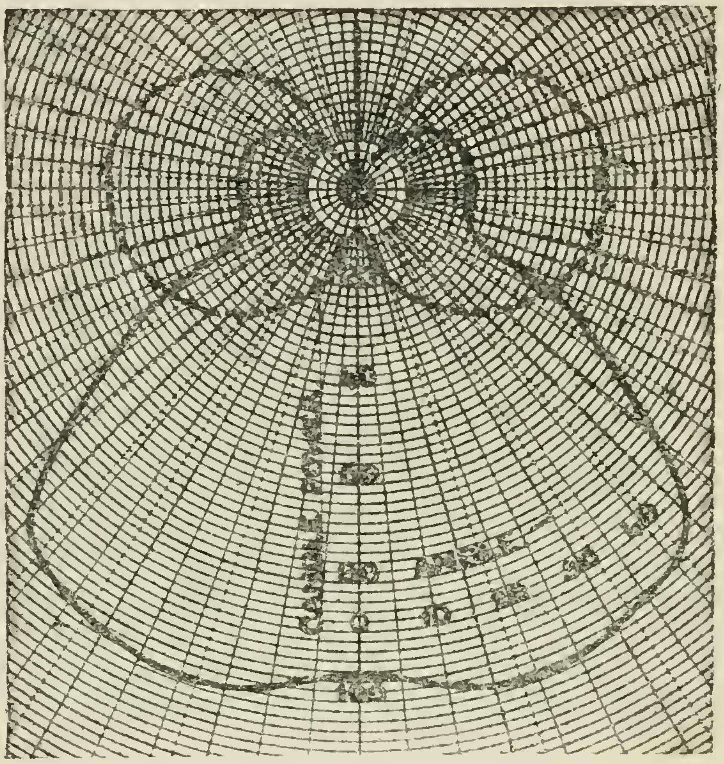


FIG. 17A.—Chart illustrating the manner in which the Reflector intensifies the effect of the rays of light emanating from the bulb within it.

the door, for convenience of those entering to clean the room: the remainder ought to be within easy reach of the teacher's desk. This arrangement is found to be the best and the least wasteful.

The minimum of light required is one candle-foot, but under special circumstances this may be profitably increased: the maximum is five candle-feet. It must be borne in mind that whilst the eye—by

movement of the iris-pupil—can adapt itself in distant vision to diverse intensity of lighting, it cannot similarly do so in near vision as when used for reading.

The windows should be protected by blinds which arrest the sunlight, and at the same time diffuse it: they should be white, or made of holland, and never be of any dark material. They ought to be affixed to the surface of the wall in the room; and not against the window-frame itself, although this might be more usual. The blind should be wide enough to overlap the wall by 3 in. on each side, and thus effectually conceal the whole window recess. By this means the entrance of any strip of light at the side of the blind is prevented—which is often so disturbing, especially when the blind is drawn and keeps flapping before an open window.

They should be spring-roller blinds, and two of them arranged at each window—one above, drawing downwards in the ordinary manner; and the other placed at the bottom of the window recess, unrolling upwards. The cord of this latter is carried up over a central pulley at the top, then passed along to the corner, and down again at the side.

By such means the regulation of the light admitted becomes perfectly simple; because the size, as well as the position of the aperture between the blinds, can be varied at will; moreover, as each blind separately can cover the whole length of the window, when still greater shade is required in the room both of them may be fully extended, one over the other, at the same time.

The walls and school-furniture must be of some pale colour, so as to reflect light and not absorb it.

The black-boards should not be made of painted

wood, because that holds the grit of the chalk and becomes grey; slate, too, presents the same disadvantages; if employed at all, both must be frequently washed, and the chalks should be only white or yellow. When the boards are not in use they should be reversed to show a lighter coloured surface; this increases the internal illumination by as much as 50 per cent., which is not any figurative statement, but is based on actual observation. When the black-boards cannot be thus specially arranged, white covers can be thrown over them.

The more perfect form of board, however, is formed by a sheet of thick, or plate-, glass, with its exposed surface frosted. (This can be effected in the usual manner; or, if of necessity, by the simpler expedient of scouring it evenly with another piece of glass and the liberal use of fine wet sand.) This is then painted white on the reverse side, and secured by simply resting it on hooks against the wall, or mounted in a frame if it must be movable. A large sheet of opal glass with its exposed surface roughened, equally answers the same purpose. Chalks of any colour may then be used.

On wall-maps and charts, the letters and figures should be of the size of test-types intended to be read at 12 metres, which is a letter 18 mm. (or about $\frac{3}{4}$ of an inch) high; the background should be of some light colour, so that the printing may show clearly.

For desk-work the pupils ought preferably to use pencil and white unglazed paper; if slates must be employed, however, the white opal ones are those recommended.

The size, shape, and arrangement of the type in

schoolbooks is of the utmost importance. The paper must be of good quality so that the type does not emboss the reverse side in the printing; nor must its surface be an absorbent one which readily stains. The type for children over nine years old must be of bold Pica size:—

This is printed in Pica size.

Below that age the type should be Double-Pica size, or only slightly smaller:—

This is printed in Double-Pica size.

Whilst the letters are sufficiently spaced, the intervals between the lines should be well separated or leaded. The length of each line should not exceed 4 inches, and if the page is a large one—as when of quarto size—the printing should be divided into two parallel columns on the one page, placed side by side, and separated in vertical direction by a space of $\frac{3}{4}$ of an inch (or $3\frac{1}{2}$ mm.); the length of the printed lines in each of these parallel columns is $2\frac{1}{2}$ inches (or 57 mm.).

With regard to the arrangement of the children, their seats and desks should be adjustable, and every six months altered in accordance with the individual measurements of the pupils. The soles of the feet must rest comfortably on the ground; the seats level, and with a support for the child's back reaching to the shoulders. The surface of the desk should be inclined at 10° downwards towards

the body, and low enough to allow the forearm to rest comfortably on it when writing; and whilst not high enough to throw the shoulder up, it should be sufficiently so to prevent stooping when at work, as it is essential to enforce the upright position. The paper or book is to be placed on the desk, so that both eyes are at equal distance from it; this means that it is to be kept centrally before the child, who must not twist the head round to one side in looking at it.

Concerning the methods of education to be followed, no child under six years old should be taught to read; and even if at kindergarten before this time, the work must be as coarse as possible, black on white, or white on black, or in contrasting colours.

Much variation ought to be given in the course of teaching, and with the avoidance of too great employment of the eyes for near-work, as reading and writing.

Frequent intervals should be given for rest and recreation, so as to relieve the strain of the eyes as well as the brain. Physical drills and exercises encourage the use of the larger muscles, whilst the finer and more delicate muscles of the eyes are rested; at the same time the general health and well-being of the children are thus promoted.

Term examinations should be abolished, as the work connected with them throws an excessive strain on the eyes. They should be replaced by average deductions, based on the general work of the preceding year.

The total duration of school hours must also be controlled. A healthy child before the age of ten

years, may spend twenty-two hours a week at school lessons, exclusive of gymnastic exercises: between ten and thirteen years old, twenty-five to twenty-eight hours: and beyond thirteen years old, as many as thirty-two hours weekly.

The preparation of lessons ought never to occupy more than one-fifth of the daily school time for children under thirteen years of age; and not more than one-third of school hours after that age.

The home preparation of lessons ought to be discouraged, because children follow their own inclinations in reading and writing, and as to the position of chair, table, book, and lighting; also they are too apt to work late until bedtime, with the result of disturbed and profitless rest and slumber. All this, in addition to the confinement and restraint entailed, proves an excessive tax, not only on the child's general strength, but also on the eyes and eyesight. Another most baneful habit, in which children often indulge unchecked at home, is to read when lying down; this cannot be too strongly condemned, as it congests the eye and conduces to the occurrence of myopia, or to its increase if already existing.

In the case of backward children, or those with defective sight—even when corrected by spectacles—the whole course of their school career should be lengthened, and also be made elastic.

The following is a summary review of the salient points here enumerated:—

(1) Children should not be taught in school earlier than six years old.

(2) On first entering the school and again annually afterwards, each scholar should have the sight

tested; and spectacles, if necessary, must be prescribed by a qualified doctor. The vision is thus kept up to the normal standard, and the eyes are relieved from strain otherwise caused by imperfect vision.

(3) Children with disease or affection of the eyes should at once receive special attention.

When children have any inflammation of the eyes, accompanied with discharge, they should be rigorously excluded from coming in contact with other pupils, and until the case has been certified as non-contagious.

(4) The correct admission and adjustment of light in the schoolrooms.

(5) Artificial illumination must be opposed so long as there are means of introducing daylight.

(6) The seats, desks, books, and paper must be suitable.

(7) The hours of study are to be regulated: the teaching must be varied, and with frequent interruptions and intervals throughout the day. The preparation of lessons at home is to be discouraged: and term examinations for promotion in the school should be replaced by some other method less harmful to the eyes.

PART II

VISUAL ACUITY

VISION REQUIRED IN PUBLIC AND OTHER SERVICES

THE medical practitioner is not unfrequently called upon to express an opinion, in the case of young patients, as to whether the eyesight is sufficiently good to pass the standard required for Government or other Services. This occurs more particularly when the question has to be decided in view of their being entered upon some special course of training.

The following facts bearing on this subject, and which are of recent date, will provide a ready means of reference for this purpose.

Another function that likewise occasionally devolves on the practitioner to perform, is that of Examiner or Referee for vision-testing, on Shipping and Railway Systems in various parts of the world; and the following notes will serve as a guide for the conduct of such examination, or for the elaboration of any fresh regulations, or for the improvement of existing ones where there is desire for it. Such rules are more particularly required where the public safety is concerned, and these observations have

therefore been restricted to the positions of employment where such a responsibility exists; whilst the standards for clerical or other work, where their stringency may be relaxed, can be readily inferred in accordance with the varying local circumstances.

It may be of some use to construct an example of the most important features which should characterise such rules for the examination of vision on Shipping and Railways.

(1) Distant vision should be tested by Snellen's or other similar system of test-types.

(2) Colour-perception should be tested by means of a lamp, the best form of which is Edridge-Green's[1]; this may be supplemented by coloured wools. Other coloured objects would be equally suitable, provided that the colour is a distinct one, and that there is no indication of any variation or difference in colour owing to the nature of the texture, surface, or other qualities pertaining to the article so used. Ignorance of colour-names should be a reason for temporary rejection. The examiner should possess a normal colour-sense.

(3) The field or area of vision should also be tested.

(4) Re-examination should occur at intervals of not less than three to five years, as circumstances permit, up to the age of forty-five; after that, at more frequent periods. It should also be made on transfer to another grade of employment, on promotion, also on any reported special defect of duty; after any serious illness, injury to the head or eyes, and excessive abuse of alcohol or tobacco.

(5) Every candidate on entry should possess normal vision (V. = $\frac{6}{6}$), with each eye separately and

[1] See p. 97.

without glasses. Later, at subsequent examinations, there should be reasonable relaxation of this standard, to a slight extent, as regards form vision; but no relaxation at all as regards colour-perception. And whilst on duty glasses ought not to be worn under any circumstances for those in active executive posts on ships, or for the special group of employés who are engaged in the active running service of trains (as drivers, stokers, guards, and signalmen); for there is always the risk of accidental impairment of vision if glasses are worn, by the lens surfaces becoming clouded, by breakage or by loss. An exception might be made for drivers engaged on shunting in yard service.

GOVERNMENT SERVICES

ROYAL NAVY

The following eye defects cause rejection in the entry of any candidate:—Blindness or defective vision; imperfect colour-perception; lacrimal fistula.

Naval cadets are required to have normal vision in each eye, tested separately (Snellen's tests).

In candidates for other branches, full normal vision is not required, but any visual defect must be due to error of refraction, and be capable of correction by glasses to the normal standard of vision; and the vision without glasses must then not be less than $\frac{6}{60}$ with each eye, with the ability to read D. = 0.6 of Snellen's test-types.

For assistant clerks: short-sighted candidates—in other respects fit—are specially considered.

ARMY

The Army test-types and Snellen's Optotypi (1892) are used to determine the visual acuity.

All Army candidates are subject to the same regulations for eyesight; and no relaxation of the required standard of vision is ever allowed.

Squint, or any morbid condition of the eyes or eyelids of either eye, liable to risk of aggravation or recurrence, causes rejection of the candidate.

For the acuteness of vision there are two tests: one for distance and the other for near vision.

The Army test-types are used for distant vision without glasses (except where otherwise stated below) at 20 feet: Snellen's Optotypi are used for near vision without glasses, and at a distance selected by the candidate. Each eye is examined separately, and the lids must be kept wide open during the test. Candidates must be able to read the tests without hesitation in ordinary daylight.

A candidate possessing acuteness of vision of the standards herein laid down, is not rejected on account of an error of refraction, provided that (*a*) in myopia the error does not exceed 2.5 D.; (*b*) that any correction for astigmatism does not exceed 2.5 D.; and that in myopic astigmatism the total error does not exceed 2.5 D.

Subject to the foregoing conditions, the standard of the minimum acuteness of vision with which a candidate will be accepted is:—

STANDARD I

	Right eye.	*Left eye.*
Distant Vision.	V. = $\frac{6}{6}$.	V. = $\frac{6}{6}$.
Near Vision.	Reads 0·6.	Reads 0·6.

STANDARD II

	Better eye.	Worse eye.
Distant Vision.	V. = $\frac{6}{6}$.	V. without glasses = not below $\frac{6}{60}$; and, after correction with glasses, = not below $\frac{6}{24}$
Near Vision.	Reads 0·6.	Reads 1.

STANDARD III

	Better eye.	Worse eye.
Distant Vision.	V. without glasses = not below $\frac{6}{24}$; and, after correction with glasses = not below $\frac{6}{6}$.	V. without glasses = not below $\frac{6}{24}$; and, after correction with glasses, = not below $\frac{6}{12}$.
Near Vision.	Reads 0·8.	Reads 1.

In Standard III., the standard for the test for distant vision, without glasses, for officers of the Special Reserve, will be not below $\frac{6}{36}$.

THE CIVIL SERVICE

Candidates are advised that a preliminary medical examination be sought with regard to fitness, in order to lessen the chances of disappointment; but this does not take the place of or influence the regular official examination of successful candidates which is made later.

There should be no serious defect of vision. A moderate degree of ordinary short-sight, corrected by glasses, would not, as a rule, be regarded as a disqualification; but candidates for the Custom Outdoor Service are liable to disqualification for

any defect of vision. Candidates for some other appointments of a special character would be rejected for colour-blindness; but for the Covenanted Civil Service of India and for ordinary Home Appointments it is not by itself a disqualification.

INDIAN PUBLIC WORKS DEPARTMENT

Candidates may, if they wish, undergo a preliminary examination by the Medical Board, which meets at the Indian Office on Tuesdays:—Applications must be made to the Under-Secretary of State, India Office, Whitehall, London, accompanied by a fee of two guineas, and stating the particular appointment sought; candidates pay their own travelling expenses. If considered unfit at this preliminary inspection they may, nevertheless, at their own risk continue studies, knowing that they must be finally inspected by the Medical Board, prior to examination or appointment. Moreover, if the candidate is reported apparently fit at the preliminary examination, no claim can be made for this decision to be accepted when the final medical examination is made.

Regulations as to vision:—

(1) If there is myopia in one or both eyes it must not exceed 3.5 D.; and, with correcting glasses of this strength, vision in one eye must be at least $\frac{6}{9}$, and in the other $\frac{6}{6}$, and there must be a normal range of accommodation with the glasses worn.

(2) Mixed astigmatism does not disqualify, provided the lens, or combined sphero-

cylindrical lens, correcting the error does not exceed 3.5 D.; and vision with this correction must equal $\frac{6}{6}$ in one eye and $\frac{6}{6}$ in the other, together with normal accommodation when wearing the glasses; and no evidence of progressive disease must exist in the choroid or retina.

(3) Total hypermetropia may not exceed 4 D., provided that vision (under atropine) equals $\frac{6}{6}$ in one eye and $\frac{6}{6}$ in the other, with $+4$ D. glasses or any lower power.

(4) Hypermetropic astigmatism does not disqualify, provided the lens, or combined lenses, correcting the error is not in excess of $+4$ D., and that V. $= \frac{6}{9}$ in one eye and $\frac{6}{9}$ in the other, with or without such correction. If there is corneal opacity it may disqualify if vision is less than—(*an unstated quantity*); in such case the eye must be emmetropic.

(5) Defects of vision arising from changes within the eye may exclude a candidate.

(6) A candidate may be disqualified if unable to distinguish the principal colours.

(7) Paralysis of an external muscle of the eyeball would disqualify.

INDIAN ACCOUNTS AND CUSTOMS DEPARTMENTS

A candidate may be admitted with defective sight provided that, with correcting lenses, Vision $= \frac{6}{6}$ in one eye and $\frac{6}{6}$ in the other; and that there are no morbid changes in the fundus of either eye.

Cases of myopia with a posterior staphyloma may be admitted, provided the error does not exceed -2.5 dioptres, and that there is no active morbid change in the choroid or retina.

If defective vision is due to corneal opacity, vision with the eye must be at least $\frac{6}{12}$, and $\frac{6}{6}$ in the other, without glasses.

Paralysis of an external muscle of the eye disqualifies. If there has been strabismus cured by operation, but without attainment of binocular vision, the candidate may be passed if the movement of each eye is good and vision in the two eyes respectively is at least $\frac{6}{9}$ and $\frac{6}{6}$. This rule also applies to cases of anisometropia without binocular vision, wherever there is good movement and the requisite visual acuity is present.

INDIAN FOREST SERVICE

A good physique is required, but no special examination of vision is mentioned.

INDIAN POLICE

If vision is $\frac{6}{6}$ for distance, with each eye separately and without glasses, and D. = 0.6 can be read at any distance selected by the candidate, he is fit.

He is also fit if he can only read $\frac{6}{24}$ with each eye, without glasses, and the defect be due to refractive error, which can be corrected with glasses so as to give V. = $\frac{6}{6}$ with one eye and $\frac{6}{12}$ with the other; and can also read D. = 0.8 with each eye separately without glasses, and at any distance selected by himself.

If vision is less than $\frac{6}{24}$ with each eye without glasses, although D. = 0.6 can be read, he is not fit.

Squint, defective colour-perception, or any morbid condition in either eye, subject to risk of aggravation or recurrence, will cause the rejection of the candidate.

ROYAL INDIAN MARINE

Officers are selected for this service who possess the full ordinary Board of Trade certificate of second mate; and therefore the regulations for eyesight, mentioned under the Board of Trade, would apply accordingly.

The selected candidate is examined by the Medical Board of the India Office; or, if circumstances demand, it may be made in India.

INDIAN MEDICAL DEPARTMENT

Each candidate is tested by a board of Medical Officers.

Snellen's test-types are used, and each eye is examined separately. If he can see D. = 6 at 20 feet, and can read D. = 0.6 at any distance selected by himself, without glasses, he is fit as regards vision.

If he can only see D. = 24 at 20 feet without glasses, the visual defect being due to faulty refraction which glasses can correct so as to enable him to see D. = 6 at 20 feet with one eye; and D. = 12 at the same distance with the other eye; and he can also read D. = 0.8 without glasses and at any distance selected by himself, he is also fit.

But if he cannot see D. = 24 at 20 feet without glasses, although he can read D. = 0.6, he is unfit.

Squint, inability to distinguish principal colours, also any morbid condition subject to the risk of aggravation or recurrence, in either eye, may be a cause for rejection.

The colour-lantern test is used.

UNITED STATES OF AMERICA CIVIL SERVICE COMMISSION

Defective eyesight (especially in railroad men), is cause for rejection. Those who have slight defects in eyesight corrected by glasses should wear these when presenting themselves for the examination.

SHIPPING

ENGLAND

Board of Trade, Mercantile Marine, July 1910

Candidates must have Vision $= \frac{5}{5}$ in one eye, and $\frac{5}{10}$ in the other.

Snellen's test-types are used.

Colour-perception must be of normal standard. Five test-skeins of coloured wools are employed (green, pink, supplementary red, purple, and yellow).

Allan Royal Mail Line

Candidates are tested with vision cards to detect long or short sight.

Officers are tested every voyage.

Colour-perception is tested by coloured discs and lighted coloured lamps.

Anchor Line

The Board of Trade tests are employed.

British India Steam Navigation, and New Zealand Shipping Cos.

Test-types are employed for distant vision.

Able-bodied seamen must have good visual acuity ($\frac{6}{6}$ in one eye and $\frac{6}{12}$ in the other).

Quartermasters must see the degrees on the compass.

Colour-perception is tested by Cartwright's wools (modified Holmgren); and, if doubtful, coloured lights are used: "In practice, if a man has any difficulty with wools, coloured lights settle the question at once."

Re-examination of vision is made before every voyage.

Cunard Steam Ship Co.

For all employés:—

Snellen's test-types are used.

Normal visual acuity is required.

Colour-perception is tested by ordinary tint-books.

Re-examination is made every six months.

The Officers are not thus tested, but must obtain a vision certificate every year from the Board of Trade.

Great Eastern Railway, Marine Service

All the staff are examined with the same tests on appointment as for the Railway service (*see* p. 142).

Re-examination is made every five years, or after any serious illness.

Orient Steam Navigation Co.

The Board of Trade tests are employed.

Peninsular and Oriental Steam Navigation Co.

Test-types are used for distant vision.

Normal sight is required, $\frac{5}{5}$, in both eyes.

Colour-perception is tested by coloured lamps.

Test examinations are made on entry, and as occasion requires.

Royal Mail Steam Packet Co.

The Board of Trade tests are used. This is supplemented by Commanders and Officers being re-examined at least once every twelve months.

Union Castle Mail Shipping Co.

The Board of Trade examination for form-vision is employed.

Colour-perception is tested every twelve months.

AMERICA

Steamboat Inspection Service, U.S.A. Government

Masters, Mates, and Pilots of all vessels applying for licence must produce an official certificate of

the United States Public Health and Marine Hospital Service, to the effect that the applicant is free from colour-blindness.

Snellen's test-type cards are used for distance.

No particular test is made for visual acuity, but Inspectors must be assured that the applicant has good sight. Impaired vision is sufficient cause for rejection, except when due to error of refraction that can be corrected by glasses.

Colour-perception is tested by Holmgren's wools.[1] This is made once, but on information from the Inspector it would be repeated.

Re-examinations of vision and colour are only made upon the request of the Supervising Inspector-General.

FOREIGN MERCHANT SERVICES

Recent inquiry shows that in foreign maritime services, colour-perception is tested with Holmgren's wools, in Austria, France, Germany, Holland, Norway, Russia, Sweden, and the United States of America. A somewhat different wool-test is in use in Japan.

RAILWAYS

ENGLAND

District Railway

Vision $=\frac{6}{6}$ in each eye separately, and ability to read Jaeger 1 with both eyes (allowance being made for presbyopia).

[1] See Note in Appendix, p. 177.

For colour-perception, Edridge-Green's Lamp is used.

Re-examination at intervals of five years.

Great Central Railway

Snellen's test-types are used at 20 feet.

All the staff are examined on appointment, and also on promotion; the footplate staff (drivers and firemen) are examined at the ages of forty and fifty; after that, every three years; and then annually after sixty.

If there is reason to doubt the eyesight of any member of the staff, a special examination is made.

Colour-perception is tested by wools.

Great Eastern Railway

Snellen's test-types are used for vision.

Cleaners are examined on appointment to footplate service; and every five years up to the age of sixty; after that, annually.

Eyesight is re-tested on promotion to other grades, and also if reason to suspect any defect.

Colour-perception is tested by Holmgren's wools. If enginemen and cleaners fail in the test for colour, they are further examined by means of flags and lamps.

Great Eastern Railway (*Marine Service*).—*See under* " Shipping," p. 140.

Great Northern Railway

Snellen's test-types are used for distance.

The visual acuity required is $\frac{6}{6}$ in one eye, and not less than $\frac{6}{12}$ in the other; otherwise, if Vision $= \frac{6}{9}$ with each eye they are accepted. Also there must be ability to read D. $= 0.6$ at any near distance selected.

No correction by glasses is allowed to those employed on uniform staff.

Colour-perception is tested by Holmgren's wools.

Eyesight is tested prior to entry; also on promotion. Subsequent examination depends on the way in which duties are performed.

Great Western Railway

Snellen's test-types are used for distance.

The regulations observed are in accordance with the directions of the Committee of the Royal Society,[1] 1892.

Colour-perception is tested by Holmgren's wools.

London, Brighton and South Coast Railway

Each eye is tested separately, both for distant and near vision.

Lads in the locomotive and signal departments, under eighteen years of age, must have $V. = \frac{6}{6}$; and after thirty years of age, $\frac{6}{9}$ in each eye.

Other members of the staff must have $\frac{6}{9}$ in each eye; or $\frac{6}{9}$ in one and $\frac{6}{12}$ in the other eye.

Colour-perception is tested by the Edridge-Green Lamp in all permanent employés; temporary employés are tested only with coloured wools or coloured glasses.

There is constant re-examination at short intervals of the footplate staff (drivers and firemen), after the age of forty.

London and North Western Railway.

Snellen's test-types are used for distance.

Candidates are examined on admission. For the

[1] See Note in Appendix, p. 174.

outdoor traffic department, visual acuity without glasses, and each eye separately, must be $\frac{6}{9}$. Squint and chronic diseases of the eye or eyelids disqualifies. Colour-perception is also tested.

Porters and others not engaged on traffic require the same visual standard, but are not tested for colour.

Colour-perception is examined with Holmgren's wools, supplemented by a colour-lantern test in certain cases.

There is an annual examination of the outdoor staff by Dot-card test; and those not passing this are sent up for special medical examination.

London and South Western Railway
(*Locomotive and Traffic Depts.*)

Snellen's test-types are used; each eye is tested separately, and vision must be $\frac{6}{6}$ in one eye and at least $\frac{6}{12}$ in the other.

Any high degree of refractive error disqualifies, also strabismus.

Colour-perception is tested by Holmgren's wools, and afterwards with a lantern test (Edridge-Green, etc.).

All men in the locomotive department are examined every third year. In other departments it varies according to the duties involved.

London, Tilbury and Southend Railway

Snellen's test-types are used at 18 feet Visual acuity must be $\frac{6}{6}$ with both eyes, or $\frac{6}{9}$ with one eye and $\frac{6}{12}$ with the other.

Colour-perception is tested by matching—not naming—coloured wools.

Re-examination for cleaners, firemen, guards, and

signalmen before promotion; otherwise every fifth year, both for visual acuity and for colour; also after serious illness or accident.

METROPOLITAN RAILWAY (LONDON)

Snellen's test-types are used.

Colour-perception is tested by Holmgren's wools.

MIDLAND RAILWAY

The Dot-card test[1] is used for vision at 15 feet, and each eye is tested separately.

All fresh applicants are tested for vision and for colour.

Before appointment the vision is tested by a medical practitioner.

Colour-perception is tested by Holmgren's wools.

If at all defective in vision or in colour, an outdoor test is made by flags for daytime, or lamps by night, at a distance of 600 yards.

Re-examination of all traffic employés is made periodically, varying from six months to two years.

NORTH EASTERN RAILWAY

All candidates for employment (except clerks) must have Vision $= \frac{6}{6}$ in either eye.

Colour-perception is tested by Edridge-Green's Lamp.

Re-examination is made on promotion.

SOUTH EASTERN AND CHATHAM RAILWAY

Snellen's test-types are used for distance at 6 metres.

On entering service V. $= \frac{6}{6}$ in one eye and $\frac{6}{9}$ in

[1] See Note in Appendix, p. 174.

the other. If there is any defect in drivers or firemen, a further test is made with signals at 400 yards.

Colour-perception is tested by Holmgren's wools, and with coloured lights and flags. (The wool-test is being replaced by the Edridge-Green Lamp.)

Underground Electric Railway (London)

Snellen's test-types are used for distance at 6 metres. Each eye, separately, must have $\frac{6}{9}$.

Colour-perception is tested with the Edridge-Green Lamp. (Colour testing by reflected light, as in Holmgren's wools and by matching colours, has been discarded for some years.)

WALES

Cambrian Railway

The Military Dot-card test is used on first appointment. Each eye is tested separately, and then together, in a good light out of doors. Candidates are also tested with actual signals.

Colour-perception is tested with cards by naming the colours; then by matching wools. Coloured lanterns must also be named at 300 yards distance; this is always carried out at night; if at all doubtful, two lanterns are employed side by side.

SCOTLAND

Caledonian Railway

The Dot-card test is employed for vision and is also used for colour-perception.

Candidates are examined on admission; and those working on traffic, annually.

Highland Railway

The Dot-card test is used at 15 feet for form-vision.

Colour-perception is tested by naming colours, also at 15 feet.

North British Railway

The Dot-card test is used at 15 feet, and each eye is tested separately. Before appointment, candidates are examined for vision and for colour.

Colour-perception is tested by coloured skeins of wool.

Re-examination on each promotion; otherwise, every three years.

IRELAND

Dublin and South Eastern Railway

Snellen's test-types are used, and each eye is tested separately.

The vision required is $\frac{6}{6}$.

Colour-perception is tested with coloured skeins of wool.

All are tested on entry: engine-drivers and signal-men are re-tested at repeated intervals, and when any evidence of defect is reported.

Great Northern Railway (Dublin)

Snellen's test-types are employed; also the Chart of the Optical Institute of London.

Vision must $= \frac{6}{6}$.

Colour-perception is tested by Edridge-Green's Lamp; and also by "Negative Wool List."

Examination is repeated every six years for the general staff. Drivers are examined for sight and for colour every two years, up to fifty years old, and afterwards annually; also after severe illness.

Midland Railway (Belfast)

Vision and colour are tested before engagement; the running department on promotion, and at intervals of three years afterwards.

AUSTRALASIA

(*See* p. 154)

NEW SOUTH WALES

New South Wales Government Railways

Snellen's types are used for distance testing.

For drivers, firemen, guards, and signalmen, on entering the service as such, or positions which in ordinary course of promotion would lead thereto, the standard of vision required in each eye is $\frac{6}{6}$; and hypermetropia, if present, must not exceed 1.5 D. in either eye.

On re-examination the drivers, firemen, and signalmen must have $\frac{6}{9}$ with both eyes open, but neither to be less than $\frac{6}{24}$. If vision is less than $\frac{6}{9}$, but not less than $\frac{6}{12}$ with both eyes open, and neither eye being less than $\frac{6}{24}$, a man is allowed a 'practical test' at 700 yards. If this proves satisfactory he may retain his post.

Guards on re-examination must possess not less than $\frac{6}{12}$ with both eyes open, and neither eye less than $\frac{6}{36}$. Where vision is less than $\frac{6}{12}$, but not

less than $\frac{6}{18}$ with both eyes open, they will not be disqualified if they can satisfactorily pass a 'practical test' with fixed and flag signals at 600 yards.

The colour-sense is tested by Holmgren's wools and a modification of Dr. Williams' Lantern.[1]

Re-examination is made every four years until the age of forty-five; and then as often as is considered necessary by the Medical Officer, but at intervals not exceeding two years.

New South Wales Government Railways and Tramways

For those entering the service of the Chief Commissioner, the tests for eyesight (form and colour) are :—

Snellen's test-types at 20 feet.

Williams' Colour-Lantern at 20 feet.

Holmgren's wools.

No one is admitted to the service of the Chief Commissioner in any capacity for working the trains and trams, or in positions leading thereto, unless certified by the Medical Officer to have normal vision in both eyes and no condition that is likely to impair them. All juniors (under twenty-one), irrespective of the nature of their work, must possess normal vision on appointment.

For those in the service—engine-drivers, firemen, and signalmen—they must have Vision $= \frac{6}{9}$ with both eyes open, and neither eye less than $\frac{6}{24}$. Where vision is less than $\frac{6}{9}$, but not less than $\frac{6}{12}$ with both eyes, and neither eye less than $\frac{6}{24}$, employés are not disqualified if they pass a 'practical test' with fixed and flag signals at 700 yards; but these men must be examined every year, or oftener if required.

[1] See Note in Appendix, p. 179.

For colour-sense they must be able to correctly select from twenty-four skeins of coloured wools, six each of red, yellow, green, and purple; and also be able to correctly distinguish the colours in Williams' Lantern at 20 feet.

Re-examination is made every four years until forty-five years old, and whenever the Medical Officer considers it necessary, but not less frequently than every two years after that age is passed. Also on promotion to a higher grade, unless satisfactory examination has been passed within the last twelve-months, or after an accident where a signal has been wrongly exhibited or wrongly interpreted; after injuries to the head or eyes, or after any serious illness. If there is reason to suspect deterioration of vision subsequently to the last examination, further examination must be made irrespective of the date of the previous one.

In using Dr. Williams' Lantern test, the blue light is eliminated and only the two larger discs are used.

The 'practical test' is made with signals at any convenient station, and the test is made with both eyes, and also with each eye separately. Daylight testing alone is employed, as the Williams' Lantern is accepted as sufficient for the night test.

QUEENSLAND

Queensland Government Railway Service

Snellen's test-types are used for distance at 20 feet, or 6 metres.

Every candidate for employment must be able to see $\frac{6}{6}$ with each eye separately and without glasses;

and be able to read D = 0.6 at any distance selected by himself. If he can only see $\frac{6}{9}$ or less, he is rejected.

Colour-perception is tested by Holmgren's wools in daylight, and the candidate is not required to name the colours but only to match them.

The question of periodically examining the employés of the running staff who have reached sixty years of age is under consideration.

South Australian Railways (1905)

Every candidate for employment must, at the time of application, produce a satisfactory certificate as regards the condition of his eyesight.

Vision is tested with Snellen's types at 20 feet.

Colour-sense is tested with Holmgren's coloured wools and Dr. Williams' Lantern.

The standard here quoted applies :—

(*a*) To future admission of men dealing with signals.

(*b*) To men already in the service dealing with signals.

These comprise drivers, firemen and cleaners, guards, signalmen, shunters, station-masters, etc.

There is a further classification of those employés who do not deal with signals, but they do not come under consideration here.

Vision in class (*a*) of the foregoing must have $\frac{20}{20}$ in each eye without spectacles, and no disease which would impair the vision.

In class (*b*) not less than $\frac{20}{40}$ in each eye, and no disease which might further impair vision.

The colour-sense in both these classes must be perfect.

Re-examination of vision and colour-sense in class (*b*) takes place—

(1) Every four years until forty-five years old; then as often as deemed necessary by the Railway Medical Officer, but not less than every two years.

(2) After any accident (even though trivial); after any serious illness or occurrence which casts doubt on the employé's vision.

(3) On transference from any position in the service where signals are not dealt with, to a position under class (*b*); in this case the standard of vision required is the same as that for class (*a*).

Officers must report any employé who displays difficulty in carrying out duties when apparently due to defective vision.

VICTORIA

Victorian Government Railways

In the traction department of the railways the eyes of candidates for employment, after passing the full normal standard ($\frac{20}{20}$), are tested under homatropine, to disclose refractive error, disease of fundus, etc., which might interfere with vision in later life. Under homatropine an error of 0.5 D. of astigmatism, or 1 D. of hypermetropia, is allowed.

Snellen's test-types are used for distance; this is supplemented in the running, shunting, and signaling staffs by further examination with the ophthalmoscope under homatropine. This latter method only applies to fresh candidates, and is not used

subsequently unless under the advice of the Medical Examiner.

The colour-sense is examined by Holmgren's wools and Dr. Williams' Lantern. When the testing is conducted by a lay Examining Officer, Holmgren's wools alone are used.

All candidates for employment as drivers, firemen, stokers, guards, and signalmen must have $\frac{20}{20}$ in each eye separately and without glasses, and must have perfect colour-sense.

Re-examination is made by the Medical Examiner every four years until the age of forty; then every three years until fifty years old; and every two years afterwards, unless more frequent examination is necessary. Also after any serious illness or accident which might affect the vision and colour-sense. If any disease of the eye is disclosed on re-examination, further observation must be made annually, or even more frequently if considered necessary.

The foregoing employés at re-examination must possess not less than $\frac{20}{30}$ in one eye and $\frac{20}{40}$ in the other; and colour-sense must be perfect. Allowance is made for presbyopia according to age.

WESTERN AUSTRALIA

Western Australian Railways

Distance vision is examined by a test-card, and a practical test with signal arms by day and signal lamps by night, at distances of 100, 300, and 500 yards.

The colour-sense is also tested by Holmgren's wools.

When any doubt exists in the mind of the

Departmental Examiner, the case is specially tested by the Department's Consulting Ophthalmic Surgeon.

The standard of normal vision and perfect colour-sense are required in new appointments to positions connected with the running of trains and the safety of the lines.

A new set of regulations is being elaborated in accordance with the subjoined report of the Inter-State Railways Conference.

Australasian Railways

Inter-State Conference of the Commissioners and General Managers of the State Railways held in Sydney, 4th May 1904.

Distance vision to be examined by Snellen's test-types at 20 feet.

Colour-sense is tested by Holmgren's wools and Dr. Williams' Lantern.

All candidates for the running service must have $\frac{20}{20}$ in each eye without spectacles, and no disease impairing the vision, and the colour-sense must be perfect.

On re-examination each must have at least $\frac{20}{30}$ in each eye, and be free from disease, and the colour-sense still be perfect.

Re-examination is made every four years until forty-five, and then as often as considered necessary by the Medical Officer, but at least every two years; also after any accident (except trivial ones), and after any serious illness or occurrence that casts doubt on the visual capacity of the employé. Also on transfer from one class of employment to another.

CANADA

Canadian Pacific Railway

Snellen's test-cards are used for distance.

The vision of engineers, firemen, conductors, and signalmen on entering service must be $\frac{6}{6}$, without glasses, in each eye separately.

Employés may only wear glasses when reading test-print or train orders.

Colour-perception is tested with Holmgren's coloured wools, also with coloured-lantern test.

All the above named, except signalmen, are re-examined on promotion, or at any other time when called upon; the standard of vision must then be $\frac{6}{9}$ with both eyes open, each eye being separately tested. Signalmen on re-examination must have Vision $= \frac{6}{12}$.

Grand Trunk Railway Co. of Canada

Vision is examined by means of soiled flags as used in ordinary day service, and standard lanterns as at night. This is conducted at the several distances of 200, 400, 600, and 880 yards; and special note is made of the weather conditions at the time of testing.

The examination is conducted by officials of the Company in their respective departments; in case of doubt the employé is referred to one of the Company's appointed oculists, who reports to the Chief Medical Officer.

Enginemen and firemen must possess $\frac{6}{6}$ (normal) vision in one eye, and at least $\frac{6}{9}$ in the other.

Examination is made when the employé is appointed as fireman; and later, when promoted to

be engineman. There is no regular period for re-examination; but special examination is made if there is any reason to suspect the eyesight as being at all defective.

INDIA

Great Indian Peninsular Railway

(In the locomotive and traffic departments all the men are drafted from the larger railways of the United Kingdom, and have been medically examined before being selected as candidates. Each candidate is nevertheless subjected to examination.)

Snellen's test-types and the astigmatic fan are employed, for each eye separately.

Normal vision is required in the case of drivers and stokers.

Civil engineers and office clerks must, if error of refraction is present, be able to fully compensate it by the use of appropriate glasses.

Colour-perception is also tested, with each eye separately, by Holmgren's coloured wools.

Indian Midland Railway

The same as the preceding.

NEW ZEALAND

New Zealand Government Railways

All candidates before admission are examined by a Medical Officer appointed at each centre of population.

Snellen's test-types are used at 6 metres distance.

Vision must be $\frac{6}{9}$ with each eye separately. Near-vision is examined with Snellen's reading test-types at the usual distances.

Colour-perception is examined with Holmgren's coloured wool-skeins.

The field of vision is also examined if considered necessary; but the perimeter is not used, because any necessity for it would contra-indicate the candidate being suitable for acceptance.

Re-examination is made annually, both for sight and for colour-perception, by experienced officers; and if there is any doubt, the employé is further tested by the railway Medical Officer.

If vision becomes impaired at all, the employé is transferred to some other duty not connected with train-working or signalling.

SOUTH AFRICAN RAILWAYS

(As now incorporating the 'Central South African Railways,' 'Natal Government Railways,' and 'Cape Government Railways.')

Central South African Railways

Snellen's test-types are used. Candidates are required to have vision of $\frac{6}{9}$ in one eye and $\frac{6}{18}$ in the other, without glasses.

Colour-perception is tested by Holmgren's wools.

Engine-drivers and firemen are examined every year for both vision and colour-perception. Other members of the staff engaged in working the trains are examined every third year; but when over forty-five years old, are examined annually. Members of

the staff otherwise employed are only examined on entering the service.

Natal Government Railways

Vision is examined with the Dot-test, and any candidate is rejected unless able to answer all questions correctly.

Colour-perception is tested with red, yellow, green, blue, and black squares in two sizes—measuring respectively $\frac{1}{2}$ inch and $\frac{1}{4}$ inch; as well as with semaphore arms of similar size.

At 15 feet the dots must be correctly enumerated, and also the smaller squares of colour named: at 25 feet the larger coloured squares must be correctly described, as well as the position of the semaphore arms.

Vision is tested every third year; and annually after the age of forty-five; and also after any serious illness.

Cape Government Railways

The Horse Guards' Dot-test, slightly modified, is used at a distance of 15 feet, and each eye is tested separately, without glasses, in the cases of drivers, guards, signalmen, and shunters; but station-masters and station-foremen are permitted to wear glasses.

Colour-perception is tested at a distance of 15 feet with the coloured squares (red, yellow, green, and blue) printed on the card; also with coloured flags by day, and lamps by night, at distances of 200 to 400 yards.

Employés are thus tested on promotion to engine-drivers, guards, signalmen, and shunters: in the case of engine-drivers, every two years afterwards; but in the others, on attaining to the ages of forty, forty-five, fifty, and fifty-five.

AMERICA (UNITED STATES)

Baltimore and Ohio Railroad Co.

Snellen's test-types are used for distance.

Enginemen and firemen (drivers and stokers) on road service, and firemen on yard service, on entering must have Vision $= \frac{6}{6}$ in each eye separately, and without glasses. A further test is made by adding a convex glass of 2 dioptres ($+ 2$ D. spher.) to each eye; those who can still read $\frac{6}{6}$ with these glasses are not accepted.

On promotion vision is again tested, and must be $\frac{6}{6}$ in one eye, and not less than $\frac{6}{9}$ in the other; each eye is tested separately, and without glasses.

On re-examination vision must be $\frac{6}{12}$ in one eye and $\frac{6}{15}$ in the other, and without glasses.

Enginemen on yard service must comply with the similar standard on promotion; but on re-examination vision must not be less than $\frac{6}{12}$, with or without glasses, both eyes being open and used together.

Conductors (guards) must have $\frac{6}{6}$ in one eye and not less than $\frac{6}{12}$ in the other, without glasses; and on promotion $\frac{6}{9}$ in one eye and $\frac{6}{12}$ in the other, without glasses; and on further re-examination, $\frac{6}{12}$ in one eye and $\frac{6}{15}$ in the other, with or without glasses.

Colour-perception is tested with Holmgren's wools; and in old employés whose colour-sense appears faulty, a further test with Williams' Lantern is made.

Old employés are re-examined every two years, and upon promotion.

New York Central and Hudson River Railroad Co.

Snellen's test-types are used at 20 feet; each eye is examined separately, and without glasses.

If the $\frac{6}{6}$ type can still be read when convex glasses of $1\frac{1}{2}$ dioptres (+ 1.5 D. spher.) are placed before the eyes, the applicant is rejected because of the manifest hypermetropia.

On entering service, enginemen and hostlers must have $\frac{6}{6}$ with both eyes combined, and not less than $\frac{6}{9}$ in either eye; firemen must have $\frac{6}{6}$ in each eye; these are not accepted if, on entry to service, they need to wear glasses for near vision. For signalmen, $\frac{6}{6}$ vision is required with both eyes, and not less than $\frac{6}{12}$ in either eye.

Colour-perception is tested with Holmgren's or Thomson's colour-selection test, and with a Williams' or similar lantern.

No applicant is accepted or employé retained in the service who has defective colour sense.

Re-examination is made for all grades every two years; or when employés have permission to wear glasses for distant vision; also after serious accident or illness; and before promotion, or transfer of service to another department. Enginemen with $\frac{6}{9}$ vision in either eye, and all others with less than $\frac{6}{20}$ in either eye, are examined annually; and a modified standard is then accepted, subject to the decision of a committee.

The Pennsylvania Railway Co. (Philadelphia)

Examination of candidates for employment is made, without glasses, before entry to the service.

Vision must be sufficient both to clearly see the prescribed signals and to distinguish their colour.

When employed they must pass a satisfactory examination at least every five years; or more frequently if desired. After the age of forty, re-examination is made every two years. Glasses may be worn on these occasions.

When vision or colour-perception has been affected through accident or illness, a satisfactory examination must be passed after recovery.

Enginemen and conductors are likewise submitted to examination before promotion.

Any employé who fails to pass on re-examination is referred to the appointed ophthalmic expert.

Those with defective vision which cannot be corrected with glasses are only placed in positions where this is not of importance, and they are never employed in train service.

Those with defective colour-perception are not employed where the possession of that faculty is a necessity.

Employés whose vision requires the use of glasses, and whose work is where the position or colour of signals must be seen, are obliged to wear suitable glasses in spectacle-form whilst on duty.

Near-vision is tested at the distance of 14 to 18 inches, and paragraph No. 2 of the standard-card must be read.

Employés whose vision requires the use of glasses are examined when wearing them; and also with the duplicate pair which they must possess.

Enginemen, firemen, and conductors are grouped in the first category of employés in relation to

visual acuity. On their entry, vision must be $\frac{20}{20}$ in one eye, and not less than $\frac{20}{30}$ in the other, without glasses; and on promotion this standard remains the same. On re-examination later, vision in one eye must be $\frac{20}{30}$, and in the other at least $\frac{20}{40}$.

Signalmen are placed in the second category. On entry, vision must be $\frac{20}{20}$ in one eye, and not less than $\frac{20}{40}$ in the other, without glasses. On re-examination, one eye must have $\frac{20}{30}$, and the other not less than $\frac{20}{50}$.

Colour-perception is tested with Thomson's modification of Holmgren's worsteds.

In this examination the colours are not named, as the test is based solely on the comparison of colours with the test-skeins.

Dr. Thomson's Lantern[1] for the detection of colour defects is used as well. The colours here must be rightly described by name. Inability to correctly discern red, green, or white, and especially when modified by interposed screens, prevents the candidate passing.

AUSTRIA

Austrian State Railways

Snellen's test-types are employed, and each eye is tested separately.

Employés are divided into four groups according to the demand on their range of vision.

In group A (engine-drivers, firemen, captains and crews of steamboats and ferries, guards, signalmen, and others), vision must be $\frac{6}{6}$.

In group B (station-masters and others), each

[1] See Note in Appendix, p. 179.

eye must have $\frac{6}{18}$ without glasses; but with the concave glasses usually worn, vision must be $\frac{6}{6}$.

Hypermetropia is only allowed when vision without glasses is $\frac{6}{6}$.

Colour-perception is tested binocularly, with pseudo-isochromatic tables (Stilling, Nagel),[1] as normal test; and with Holmgren's wools as an alternative one. When there is any doubt about the colour-test, the chief medical officer makes a control test examination with the Anomaloscope (Nagel). When three examinations have shown that the colour-perception is normal, further testing may be discontinued.

Employés in these two groups are examined every five years, dating from the last examination, up to the age of forty-five; from forty-five to sixty, every three years; and from sixty, every two years.

On re-examination, employés must see $\frac{6}{18}$ with both eyes and without glasses, and colour-perception must be normal. Re-examination is also made after accidents and sickness.

In hemeralopia, cases are examined every year; and in cataract, every half year. Hemeralopia precludes employment so long as the condition continues. Presbyopia does not debar the capacity for executive service, and these employés may use glasses for night work.

FRANCE

Chemin de Fer de l'Est

The Monoyer test-types[2] are used for distance at 5 metres.

[1] See Note in Appendix, p. 178. [2] See Note in Appendix, p. 175.

All candidates are examined on entry, and are divided into four groups. In the first of these, drivers, firemen, guards, signalmen, and others are classed together; they are not allowed to use glasses on duty. The sum of the visual acuity in both eyes together must be $\frac{12}{10}$ ($= 1.2$); but in neither eye, separately tested, may vision be less than $= 0.5$. A candidate may be accepted with Vision $= 0.7$ in one eye and 0.5 in the other; but a candidate having 0.8 in one and 0.4 in the other would be rejected.

Corneal opacity, myopia, hypermetropia, and congenital insufficiency of the retina, from whatever cause, which reduces vision below 0.5 in the eye affected, is a cause for rejection.

The field of vision is also tested, but roughly, with the fingers, and if much restricted it would also be a reason for rejection.

Colour-perception is tested with coloured glasses and coloured papers, also with skeins of wool. Coloured pencils are also employed as part of the test, which the candidate uses to describe the colours shown to him; thus, if he writes 'red' with the green pencil, it is evidence of error, etc.

Beyond the examination on entrance there is a re-examination afterwards, and on promotion.

Chemin de Fer du Nord

The Monoyer test-types are used at 5 metres distance.

The field of vision is tested roughly with the hand and fingers.

Drivers, firemen, guards, and signalmen are not allowed to wear glasses; these must at least possess visual acuity of 0.7 in one eye and 0.5 in the other.

Colour-perception is tested with skeins of wool, the colour of which the candidate is asked to write with a similarly coloured pencil (violet, blue, green, yellow, orange, or red).

Re-examination is made at the close of the probation stage, on transfer to another appointment, on promotion, and whenever there is reason to consider it necessary.

Chemin de Fer de Paris à Orléans.

The Monoyer test-types are used at 5 metres. If there is any question raised at this test, the examination is repeated with actual signals at a distance of 400 metres.

Examination is made without glasses, and visual acuity must be at least 0.9 in each eye separately.

The field of vision is also examined with the fingers.

Colour-perception must be perfect, and it is tested with Holmgren's wools by daylight; the field of colour-vision is also examined roughly with skeins of wool held between the fingers.

There is a re-examination if more than a year elapses from the date of the first examination until the accepted candidate enters on his post; also on promotion; after any serious illness or accident, or affection of the eyes.

Drivers and firemen are examined every ten years.

Chemin de Fer de Paris-Lyons-Mediterranée

Every individual wishing to enter the service of the Company is submitted (as a preliminary) to medical examination; a second one is made before any engagement is confirmed. When thus examined,

attention is particularly directed to the field of vision, colour-perception, and visual acuity; and each eye is tested separately and without glasses.

(1) The field of vision occupies first place in the examination, and is investigated by questioning the candidate as to the movement of the examiner's fingers when they are passed around in the periphery of the field.

(2) Colour-perception is tested in a dark room with a special lantern and coloured glasses, at the distance of 5 metres. Any candidate failing in this is rejected.

(3) Visual acuity is determined for each eye separately with Monoyer's test-types, placed in full daylight at 5 metres.

If mistakes are made, or there is hesitation, the candidate is submitted to a practical test. He is placed at 200 metres distance from the examiner (a doctor), who has an assistant standing in front of him; the latter moves or elevates the arms accord-to instruction, and the candidate is asked to imitate him. If this test is satisfactory, visual acuity is regarded as normal.

The standard of visual acuity required must be equivalent at least to the sum of $\frac{14}{10}$ for the two eyes, but neither eye must be less than $\frac{5}{10}$; this rule admits of no alteration for those employés in any positions where there is responsibility for the public safety. The only exception is in the case of some candidates who may be recommended by heads of special departments, provided that their vision can be sufficiently corrected by glasses; but these persons are restricted solely to duties in the offices or workshops.

Re-examination of the vision of all employés is made after the occurrence of any serious eye affec-

tion, injury to the head, serious general disease, alcoholism, and on any change of position in the service. It is likewise repeated every ten years for all employés connected with the traction and permanent-way departments.

If the doctor attached to the section has reason to suspect any defect in vision, the case is submitted to a specialist, of whom one is nominated to each of the six central depots of the Company.

Those employés who develop visual defect can only remain in the service after passing a practical test; this is made, both in daytime and at night, with signals placed at their ordinary distance. Nevertheless, these individuals are no longer employed on train service; they cease, too, to be permanent employés, and the term of their engagement becomes temporary. They are examined annually, or oftener if the specialist considers it necessary; and if called upon to do so, must retire from the service.

Tables of analyses are shown of the results of such examinations as carried out on the several grades amongst the employés.

The foregoing rules work so satisfactorily, that in a report addressed to the Minister of Public Works in 1903, it was stated that throughout this railway system no accident could be ascribed to there having been error in reading a signal.

GERMANY

Imperial Ministry of Railways

This includes the several railway systems of the different component States, the directors of

many of which select their own method of vision testing.

The Prusso-Hessian Railway has published a pamphlet on the subject, and similar regulations exist for the State Railway in Baden.

Snellen's test-types are used.

Special attention is devoted to the eye, including the external condition of the eye and eyelids, central visual acuity, refraction, and the colour-perception,

The standard of visual acuity required depends on the nature of employment on the railway, and for this employés are divided into four groups. In the first of these are placed drivers, firemen, and signalmen, besides others.

On entering service vision must be at least $\frac{6}{9}$ in each eye, without glasses and tested separately.

On re-examination they must in the same way have $\frac{6}{9}$ in one eye, and $\frac{6}{12}$ in the other. In the event of vision in one eye being less than $\frac{6}{12}$, the individual is submitted to a practical test by an appointed local authority; he is then made to distinguish, with absolute certainty, indicators or signals placed at a distance of 300 metres. Provided this can be done, his services are retained; but in the case of failure, he is either dismissed or transferred to another department where a lower degree of visual acuity is required.

Colour-perception is determined by Professor Nagel's colour plates.

Some of the railways test the chromatic sense with Stilling's colour plates; or with Holmgren's coloured wools; or by the method of Daae, or Cohn,[1] or of Schmidt-Rimpler, or others.

[1] See Note in Appendix, p. 176.

Each doctor conducting this examination must be proved to possess normal colour-sense.

The period elapsing before re-examination of eyesight (visual acuity and colour-perception) varies, but is made on the majority of the railways every five years; although on some it is every three years. It is also made on transference of the employé to a post where a higher standard of vision is required; also after serious illness, eye affection, or injury to the head.

ITALY

The State Railways

There is an examination of the eyes and vision (visual acuity, colour sense, and field of vision) for every candidate on entry; and the vision is also examined on promotion, or on transference to another duty where a higher grade of sight is demanded. The first examination, however, is accepted if promotion occurs within a period of three years afterwards.

Re-examination is made if any doubt arises at any time, or after disease or injury implicating the head or eyes, or after any serious general illness; likewise if there is any abuse of alcohol or tobacco. A further compulsory re-examination of vision (similarly as to the acuity, colour-sense, and field of vision) occurs for certain special grades of employés at the age of forty-five and at periods beyond that.

The visual requirements of employés, in all the several grades and positions, are minutely tabulated by the Railway Administration.

Engine-drivers on joining require to have Vision

$=\frac{6}{6}$ in each eye separately without glasses, and normal colour-sense and field of vision. On transfer of duty the visual acuity in the two eyes, when added together, must be equivalent to a sum not less than $\frac{18}{10}$; at the age of forty-five this must be $\frac{14}{10}$, and still without glasses.

For firemen (stokers), on transfer of duty, the sum of vision of the two eyes must be at least $\frac{14}{10}$; and at forty-five must in the same way be $\frac{10}{10}$.

Guards on re-examination require to have the sum of vision of the two eyes not less than $\frac{14}{10}$; and glasses of 2 dioptres, either convex or concave, are then allowed to be worn by them.

Signalmen on joining must have Vision $=\frac{10}{10}$ in each eye separately without glasses, and the colour-sense and field of vision normal; on promotion, or on transfer, the sum of vision of the two eyes must be not less than $\frac{18}{10}$, without glasses, and the colour-sense and field of vision normal. On re-examination at the age of forty-five, the sum of vision of the two eyes must be at least $\frac{14}{10}$ without glasses, the colour-sense for red and green normal, and the field of vision not restricted.

Colour-perception is examined with Holmgren's wools.

JAPAN

Imperial Government Railways

For those employed on the actual running service (enginemen, stokers, and guards), examination of vision is made once a year, and those disqualified are transferred to other departments or are discharged.

Diagrams after Snellen's system are used for dis-

tance at 20 feet (6 metres); they must be clearly distinguished by both eyes. Also the shape and colours of stationary signals must be clearly distinguished at the distance of 40 chains (880 yards, or 804.6 metres).

Near-vision is tested by a figure placed in a circle of $\frac{1}{2}$ inch (12.6 mm.) diameter, which must be clearly identified at a distance not exceeding 20 feet.

The field of vision is examined by the candidate being placed 3 feet away, and looking straight forward; the examiner stretches his own arms at full length, and requires the individual to recognise the opening and closing of the hands.

Colour-perception is tested with suitable coloured objects (red, green, white, black, light purple, and deep orange colours).

Squint, hemeralopia, lacrimal fistula, or other affections and diseases of the eyes and eyelids, disqualify.

NORWAY

Principal Norwegian Railway

Snellen's test-types are used for distance, at either 5 or 6 metres in full daylight, or with good artificial light.

Both eyes are tested together, then separately; and in both instances without glasses.

Every default is noted.

Those employés concerned with the public safety (engine-drivers, guards, and signalmen) must have vision with one eye equivalent to $\frac{6}{8}$, or $\frac{5}{6\cdot6}$, at least; and not less than $\frac{6}{12}$, or $\frac{5}{10}$, with the other.

Re-examination is made every fifth year, or oftener if required; also on transfer of duty and on promotion.

Colour-perception is tested by several methods. These are:— Holmgren's wools; O. B. Bull's test[1] with mono-coloured squares; A. Daae's test, in which the horizontal lines that contain the same colours (red and green) only must be distinguished, and the other portions rejected. The candidate fails if a wrong colour is ascribed to any division.

RUSSIA

The State Railways

Visual acuity is examined with a table of test-types on a white ground, arranged on the metrical system. It is artificially illuminated; for which, and its position and precise surroundings, minute instructions are issued. Each eye is tested separately.

The field of vision is determined, but only approximately, with hand and fingers in doubtful cases.

For colour-perception Holmgren's wools are used.

The frequency of examination depends on circumstances.

SWEDEN

The State Railways

Vision is tested before employment, both for regular and special work; there is no subsequent periodical inspection.

[1] See Note in Appendix, p. 176.

For colour-perception, Holmgren's wools are used.

For controlling the result thus obtained, a test with coloured lights may, if necessary, be employed.

In doubtful cases reference may be made by letter to Professor Holmgren of Upsala, for a deciding test or for advice.

SWITZERLAND

Swiss State Railways

Snellen's test-types are used for distance at 5 metres ; each eye is examined separately and without glasses.

Drivers, stokers, guards, and signalmen must have normal ($\frac{10}{10}$) vision and normal colour-sense.

Colour-perception is tested with Holmgren's wools and with Stilling's coloured tables. This may be supplemented by a subsequent examination with signals, flags, or lanterns ; the distance for this, if in the daytime, must not be less than 250 metres ; and if at night, not less than 400 metres.

Re-examination every five years ; and for those who are over fifty, every third year ; also after serious illness, eye affections, or injury to the head, or if any doubt arises in connection with vision.

APPENDIX

NOTES AND METHODS

THE following is a brief summary of the **Report of the Royal Society's Committee on Colour Vision, 1902**, which is referred to by the Great Western Railway Company:—

That a competent authority should schedule certain posts of employment in the Mercantile Marine or on Railways, which if held by individuals with either deficient form-vision or colour-vision, or ignorant of colour names, would involve danger to life or property.

That proper testing for these should be compulsory and be carried out by certificated examiners. The test for colour-perception to be made with Holmgren's wools, supplemented by a practical test with lights and signals. That Snellen's types be used for testing form-vision.

Every third year or oftener there should be a re-examination.

VISION-FORM TESTS

The **Dot-test** used on some railways, was issued from the Horse Guards in 1868. It is composed of an arrangement of a series of dots; each of these

test-dots measures 1.5 of an inch square, and at a distance of 15 feet is equivalent to a bull's-eye measuring 2 feet square as seen at a distance of 600 yards; with normal vision these dots should be seen clearly in daylight at 19 yards. This Dot-test card is placed at a distance of 15 feet, and each eye of the candidate is tested separately. There are four coloured squares (red, green, yellow, and blue), two of which are printed on each side of the dots; they also must be correctly named.

Test-Types

Monoyer.—Used on French railways. It is similar to Snellen's test-table, but the letters are of "English block" character, without ornamentation, and occupy the space fully up to the margin of limit allotted there to each letter.

Snellen (*described in present text, page* 19).—These types are obtainable in a variety of forms, for different languages and for the several kinds of script.

For those who are unable to read (Illiterates) there are various forms of test-types. The method of Snellen has been adapted to a sign drawn in the shape of a trident or the figure E turned in one of the four principal directions; or, again, to that of a square with one side omitted ⊔. When a series of these in lines of graduated size are used, instead of ordinary letters, the test is quite as accurate—even although it may be more readily discerned—provided that when any series of comparisons are made, each of the cases is tested with it. It is advisable to restrict the position of these special characters to one of the four cardinal directions,

pointing up, down, to the right, or to the left; intermediate positions are apt to be confusing, and difficult for an uneducated person to describe readily. The same remarks apply to the Optotypi character (C), described by Landolt.

In all the foregoing the fingers or hand may be used by the patient to indicate to the examiner the position of these characters, or letters, as this avoids any risk of dubiety; or a wooden, or light metal, pattern of the same shape may be similarly used.

For children the above answer admirably; also various simple outline pictures have been designed, likewise adapted to the Snellen scale.

COLOUR-PERCEPTION TESTS

Coloured Wools

O. B. Bull (Christiania).—This is an apparatus in which the four principal colours (red, yellow, green, and blue) are represented in squares, measuring 2 cm. each, painted on a small round disc; this is placed under a second plate which is black, and there is a common central pin around which the first disc can be turned. Any of the four colours can thus be brought before the quadrilateral opening in the upper disc.

Cohn.—1. Coloured wools.
2. Coloured embroidery.
3. Coloured pigment in small phials; the idea being to avoid giving any indication of colour by difference of surface or texture.

A. Daae (Christiania).—This is based on Holmgren's

test. There are ten horizontal lines, each composed of seven little squares of coloured wools. In only two of these lines are all the colours similar, though varying in shade ; one line is green and the other red. The other lines contain different colours.

If any of the other lines appear to an individual to consist of shades of the same colour, it is an indication of colour-blindness, and the different lines betoken varieties of the defect. (While it is a convenient test, in most cases a supplementary one is required.)

Holmgren (Upsala).—This is a series of Berlin-wool skeins of different colours, and shades of the same colour; and there should be at least five gradations of each tint. There are three test-skeins with which these are compared—a light green, a pale purple or pink, and a light red.

W. Thomson (Philadelphia, U.S.A.).—This is a test-stick, composed of two flat halves closed together and hinged at one end. Concealed between them are forty white buttons consecutively numbered, and attached by hooks to the inner surface of one of the sticks : this admits of changing the position or of the removal of any of the forty coloured wool skeins attached to them.

There are three test-skeins (light green, rose or purple, and red). These are shown in turn to the person who must match them with the other colours on the stick, where the matching and confusion colours are alternately arranged in series. The numbers from 1–20 include green, grey, and tan of colour-confusion tints; 21–30 are alternately rose and blue; and 31–40 are red tints. Real tints commence, however, at No. 1, and range onward in

the odd figures; whilst the even figures are used to indicate the confusion-tints.

Thus, when the whole examination is concluded in a person with normal sight, only the odd figures should appear on the form to be filled up; whilst if a fault is made by a colour-blind person, it will be revealed by the even numbers similarly recorded. Any intelligent layman therefore is capable of conducting such an examination, if the results obtained are controlled by a superintendent or supervising expert.

This test has been recently modified by the red test-skein being omitted; it is known as 'the New Wool-Test' (Thomson's).

Coloured Plates

Nagel.—These are cards each having a series of little coloured discs arranged in the pattern of a ring; there are twelve rings in the set. In some the discs are all of one colour, but of different shades; in others the discs are of two or three different colours (confusion-tints). The patient is required to state which rings are monochromatic, and then has to pick out in the dichromatic or trichromatic rings all the discs of one special colour. The existence of colour-blindness is thus readily detected, and also the nature of it.

Rumble.—This is a solid disc bearing a series of smaller ones inserted near its edge, which are made of transparent celluloid of different colours. It is placed in front of a window and revolved, so that successive colours may be presented to the candidate. (*This was lately in use on the District Railway.*)

Stilling.—These are chromo-lithographic tables,

on which patterns composed of differently coloured squares—arranged in chess-board fashion—are disposed in the form of letters or figures. The colours of these squares are selected for the purpose of confusing any one who is colour-blind. The latter sees all the squares as of the same colour, and therefore cannot name the letters or figures into which they are grouped.

The test is dependent on the fact that the colour-blind person cannot distinguish two colours—which appear quite different to the normal observer—if they lie on the same side of the neutral band in the individual's dichromatic spectrum, and are of the same brightness. In Table II., for example, there are red letters on a brown ground, which cannot be deciphered by a red-blind person.

The objection to the test is that when the two colours happen to suit the colour-blind person's individual peculiarity, the letters will be recognised.

Colour Lanterns

Edridge-Green (London).—The description of this is contained in the present text (page 97.)

W. Thomson (Philadelphia).—He has designed a lantern for colour-perception which is used as supplementary to the New Wool-Test, and to the use of soiled service signal flags.

C. H. Williams (Boston, U.S.A).—This lantern presents a large disc of 18 inches diameter, which bears thirteen smaller discs of coloured glass. This may be revolved so that any colour can be brought in front of the fixed light. A movable diaphragm in front of the glasses permits of variation in the size of the disc shown. These latter openings cor-

respond in size to the component parts of letters in Snellen's test-types; *e.g.* at 20 feet a colour seen through the smallest opening corresponds to the apparent size of a switch-light signal shown at the distance of 1500 feet. If the colours cannot be distinguished, the size of the opening is increased.

The lantern has one vacant place, to allow of the regular switch-light lenses or semaphore glasses being placed in front of it, either alone or combined with smoked glass. This in actual experience occasionally occurs, and is to be guarded against; because if a red signal-glass is smoked, an employé with deficient colour-sense might see it as a green one.

The lamp at its smallest apertures is further useful for discovering central colour scotomata, as seen in tobacco amaurosis. This would escape notice if Holmgren's wools were used, on account of the peripheral area of the retina being stimulated by the larger size of such coloured objects.

PHOTOMETERS

Of Photometers one of the most efficient forms is that known as the "Holophane Lumeter," as devised by Messrs. Dow and Mackinney (the makers being R. & J. Beck, Cornhill, London, E.C.).

This apparatus utilises a round object-field—as in a telescope—the periphery of which, in the form of a broad ring, is illuminated by a small lamp of standardised strength, contained within the instrument.

The lighting of this ring is mechanically regulated until it corresponds with the other portion of light

in question; the latter is seen forming the central area and is enclosed within the ring.

The eye of the observer is kept applied to the instrument whilst making the adjustment, and the result is registered automatically on a scale, in figures expressing the degree of illumination directly in candle-foot power. Thus the need for any subsequent calculation is avoided.

This is of great value in arriving at correct results quickly and with uniform accuracy. Beyond this, the construction of the instrument is compact, so that it is very portable and can be easily held in the hand and used in any position, and its working is quite simple.

There are other excellent forms of instrument for the purpose, such as the **Globe Photometer**, by Ulbricht. This is the principal one adopted in Germany, but its large size precludes it being used outside the laboratory; it is principally employed for determining the intensity of sources of light.

There is also the **Trotter Universal Photometer**. This, used on a tripod, and in the hands of a practised operator, yields good results: a small standardised glow-lamp is used with it.

The **Marten's Illuminometer** is employed by some. This is illuminated by a small benzine lamp, the height of the flame of which requires to be regulated exactly. A certain amount of calculation is needed in arriving at the correct result with this instrument.

In the **Wingen Photometer** a benzine lamp is also used; but this, as an indicator, also causes some degree of uncertainty.

The **Harrison Street Photometer** is furnished with a small glow-lamp, and the observation depends on the

flicker which is produced by a white sector-disc; this is driven at any speed desired by means of an air-blast, which, in its turn, is generated by a double rubber ball attached to the instrument. A tripod is used, though the instrument is small enough to be portable.

Thorner's Illumination-Tester furnishes a rough idea of the intensity of daylight in a room. The brightness of an image of the sky is compared with the actual illumination of the room. But it must be recognised that many natural causes interfere with general uniformity being obtainable by such a test.

The New Universal Photometer, by C. H. Sharp and P. S. Miller, has been devised in America, and its photometric device is a modified form of the Lummer-Brodhun arrangement.

In calibrating with this instrument a known candle-power or illumination is produced by a standard lamp; the voltage or current of which is adjusted by means of a sliding rheostat, so that the pointer on the scale indicates the known candle-power or illumination. A direct reading is thus obtained.

The instrument is a hard-wood box, weighing about 8 lb., and is 2 feet in length. The movable comparison lamp is mounted within a circular metal housing; this is placed on a platform which slides along the length of the box by means of an inelastic cord passing round a revolving knob or drum.

The light from this lamp falls on an opal plate set as a window near one end. The scale from which the indications are read is made of translucent celluloid which forms part of the side. All extraneous light is carefully excluded by a special system of internal screens.

It can be used for widely differing varieties of work—the candle-power of incandescent or other lamps, street measurements, and also room measurements as regards their illumination produced by lamps.

When measuring illumination in rooms lit by incandescent lamps, it is advisable to operate the comparison lamp from the same circuit as the general lighting of the room, thus minimising the variation of voltage.

The **Luxometer** is an instrument recently devised by Messrs. Everett, Edgcumbe & Co., is based on the well-known Trotter principle, but embodies a number of other features. By its means it is possible to make any of the following measurements:—

1. Candle-power of a source of light, whether in the laboratory or out of doors.

2. Illumination at any angle, horizontal, vertical, and so forth.

3. The surface brightness of any object; for example, that of a wall-paper or the ceiling.

4. The daylight efficiency of any room; that is, the ratio of the observed illumination as compared with that which could be obtained were the walls, ceiling, etc., entirely removed.

This latter is stated to be the only true criterion of lighting efficiency, as it is independent of all conditions of weather.

The illumination to be measured in any of the above tests, is balanced against a variable illumination produced by a small self-contained metal-filament lamp, the battery for which is contained in the observer's pocket: the result is at once read off on a direct-reading scale.

The instrument itself measures 7 in. × $3\frac{1}{2}$ in. × 2 in.,

and weighs less than one pound. The usual range of its working is from 0 to 4 foot-candles, but this can be varied to suit different requirements.

Telescope Eyeglasses is the name applied to a special form of spectacles for use in the higher degrees of myopia—from about 9 dioptres upwards. The result is to widen the visual field, at the same time giving clearer definition at its periphery, with freedom from distortion.

As originally devised in Germany, these present the somewhat ungainly appearance of motor-goggles, and although smaller in size, are still comparatively heavy to wear.

At the author's instigation, Messrs. Reiner & Keeler (9 Vere Street, London, W.) have succeeded in obtaining a similar effect otherwise; with the result that the outward appearance does not differ in any way, either in size or shape, from an ordinary pair of spectacles or eyeglasses.

The heavy framework mounting has been entirely eliminated, whilst the essential advantages derived from the use of a front and a back lens are still retained. These lenses are only in contact at their edges, and enclose an air-space between their opposing surfaces. They are mounted as a single lens in the ordinary spectacle-frame.

The effect of this improved form of glasses is, whilst affording equal advantages to those first mentioned, to give markedly greater freedom from aberration, including distortion; and whilst bearing the appearance of ordinary glasses, are quite as light to wear.

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Printed by
MORRISON & GIBB LIMITED,
Edinburgh

Spring, 1911

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